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DIAMETERS OF STAR DISKS, LINES.

By W. H. PICKERING.

We sometimes see the statement made that the size of a star disk in a telescope is determined by the undulatory theory of light. This statement is quite erroneous. The size of the rings is so determined for all stars. The size of the disk for any given star is determined exclusively by the aperture of the objective. For instance with a 5-inch aperture the disk of η Tauri in the Pleiades measures 1″.6, or just twice that of its brightest companion, three magnitudes fainter (H. A. **61**, 44). The size of a star disk that is clearly defined with a 1-inch aperture was determined by Dawes some eighty years ago to be 4″.56, or 0″.91 for an aperture of 5 inches. His value appears to be rather too large for faint stars with good seeing, although fairly correct for moderately bright ones. According to him the size for an 11-inch aperture should be 0″.41. For a sixth magnitude star, with seeing 10, we found it to be 0″.26, and for one of the eighth magnitude 0″.20. A tenth magnitude star gave an image of about the same size, but the light was too faint to form a sharply defined disk. These measures were made with the Direct Vision Scale (Harvard Circular 223), and a magnification of 660.

For white threads on a black background, the smallest diameter hitherto detected measured 0″.025 or one eighth the size of the star disk. A dark hair whose real width was 0″.029 has been clearly seen against a bright background (Popular Astronomy, 1915, **23**, 579, Report on Mars No. **11**, 11). The widths of their telescopic images have not as yet been accurately determined.

Thickness of Saturn's Rings.

In Harvard Circular 223 it was stated that the inner edge of ring B, as well as the crepe ring C, might have an appreciable thickness, and it was suggested that the Pacific Coast observatories should be on the watch for its re-appearance before sunrise on February 22. We had hoped that the crepe ring itself would be visible here, but as late as February 21, 17^h G.M.T. it could not be detected with an 11-inch.

Whether the Pacific Observatories were successful in the search does not appear, but by Harvard Bulletin 742 we learn that at the Lowell Observatory the rings have been continuously visible during the past presentation, being faintest February 20, and that on February 21 at 21^h G.M.T. they greatly increased in brightness.

Since the earth passed through the plane of the rings on February 22 at 8^h, it thus appears that their northern side was first illuminated 11^h before our passage through their plane. This can only be accounted for by the fact that the inner edge of ring B and the intermediate regions were thicker than the outer edge of ring A. The excess of thickness equals 15.2 miles or 24.3 kilometers.

Since the thickness of the outer edge of ring A, as has been clearly shown by others, can hardly be more than a few miles, perhaps not more than one or two, while the thickness of the crepe ring is as we have already seen, in the Harvard Circular above mentioned, in the vicinity of 2000, it is clear that what the Lowell observers detected prior to February 21 was the crepe ring itself seen edgewise. This was perhaps all that they saw February 20, when the light was reduced to a minimum. It must then have been very difficult to determine its diameter. We last saw the whole ring with a magnification of 210, seeing 9, on February 2. It was then recorded as "extremely faint," with no condensations, but brightest near the disk. When next looked for on February 18, seeing 8, it was recorded as invisible.

Measures of the width of the shadow by means of the Direct Vision Scale have been made on several dates. Three different magnifications have been used, but in this preliminary investigation only one, that of 660 will be considered. The width on February 2 was found to be 0″.25, on February 18 0″.20 and on February 20 0″.20; mean value 0″.22 ± 0″.02. The subjective correction for this magnification is 1.78, which gives the width of the shadow as 1500 miles.

It is clear that we were observing the actual shadow, and not either the bright or the dark side of the ring projected on the planet at this time, since the projected width of the ring was only 0″.11 on February 2, and was 0″.02 and 0″.01 on February 18 and 20.

The shadow was partially concealed by the ring itself during March, and on March 6 we find it recorded as invisible. On April 7 a double dark line was seen. The narrower component crossing the center of the disk was evidently the shadow cast by the sun, which transited the plane of the rings April 10. The wider component, located slightly to the north of it, must have been the dark side of the rings projected on the planet. The seeing was too poor to measure the width of these lines, but on April 6 two measures of the wider component gave it as 0″.22 and 0″.24, April 8, 0″.22; April 9 it measured 0″.30 and 0″.26. Mean value 0″.25 ± 0″.03. The shadow was not brown, as it had been in some of the earlier observations. No irregularities of detail were detected.

The narrower component, the true shadow of the ring, was clearly seen on April 9, and was measured with a power of 660. Two measures were secured, giving it as 0″.07 and 0″.05; mean 0″.06 ± 0″.01. The appearance was very like that of one of the narrower canals of Mars.

The separation of the components was 0″.30. The seeing ranged from 11 to 9. Applying the subjective correction of 1.78, we find that

the width of the crepe ring, judged by its shadow in April, appears to be only 400 miles. This is much less than the values obtained when the earth transited the plane of the rings in November and February. Such a small angle is much more difficult to measure than larger ones of 0″.20 to 0″.30.

At the same time if this ring is composed of separate clouds of water drops, as we believe to be the case, it is quite possible that when the sun lies in its plane a greater condensation will occur in it than when the sun strikes it at a greater angle. The ring may therefore really be thinner at such times.

On February 23 four measures of the total width of the ring system, using three different magnifications, were made with a scale composed of bright lines. The results were 0″.13, 0″.15, 0″.27 and 0″.23; mean 0″.20 ± 0″.06. The subjective correction for such a scale is as yet unknown, but the results appear to confirm in general the two earlier series of measures of the shadow. Seeing 8. On April 9, just before the sun had crossed the plane of the rings, they had become exceedingly faint, but were still visible with a magnification of 660.

On April 12, when the planet was next seen, the rings were invisible, even with as low powers as 210 and 165.

The Size of Saturn's Larger Satellites.

On February 20 an interesting configuration of the satellites was noted. The rings were invisible, the planet resembling Jupiter, but conspicuously more flattened at the poles, and showing far less detail. At $17^h\ 10^m$ G.M.T. Titan was about two diameters of the planet preceding, and Dione and Rhea about the same distance following. Owing to our proximity that night to the plane of the rings, all three satellites were nearly in line thus again reminding one of Jupiter. Twelve minutes later Tethys was suddenly detected close to Titan and between it and the planet. There had evidently been an occultation which, not having been predicted, we had just missed. The diameter of Titan measured on the Direct Vision Scale, using white dots, proved to be 0″.64. Owing to the faintness of these satellites 430 is found to be a more satisfactory magnification than 660. The seeing was 12, or perfect, our atmosphere producing no detectable deterioration of the images. The diameter of the next largest satellite, Rhea, was 0″.25, Dione 0″.19, and Tethys 0″.16. There was no question as to their differing size, and the images were sharp and perfectly distinct.

It was noticed before long that Dione and Rhea were approaching one another, and that a conjunction would shortly take place. First contact occurred at $18^h\ 11^m$, the last at $18^h\ 17^m$. The occultation was not quite central, the smaller satellite passing slightly to the south. On looking the matter up in the Ephemeris the larger satellite, Rhea, was found to be beyond Saturn, and approaching eastern elongation, while Dione was nearer than Saturn and approaching conjunction with the planet. The satellites were therefore moving in opposite directions. It

was found that the occultation had occurred at the computed time, as nearly as we could determine from the ephemeris, that at contact the point of tangency, measured from the center of Rhea, lay 25°.6 south of the line of its orbit, and that the sum of the diameters of the satellites was 0″.46. This was only 0″.02 greater than the value determined by direct measurement, and thus furnished a satisfactory check.

Other measurements have since been made as indicated in Table 1, the magnification in each case being 430. None were secured of Japetus.

TABLE 1

Size of Saturn's larger Satellites

Date	Seeing	Titan	Rhea	Dione	Tethys
Feb. 20	12	0″.64 +0″.11	0″.25 —0″.05	0″.19 —0″.01	0″.16 —0″.03
Mar. 17	8	.47 — .06	.33 + .03		
Mar. 29	11	.50 — .03	.30 .00	.25 + .05	.25 + .06
Apr. 11		.50 — .03	.30 .00	.15 — .05	.15 — .04
		0.53 ± 0.06	0.30 ± 0.02	0.20 ± 0.04	0.19 ± 0.04

Using these mean values, we find for Titan 2000 miles (3200 km), Rhea 1100 miles (1800 km), Dione 800 miles (1300 km), Tethys 700 miles (1200 km). These values are much smaller than those given by Young, based on photometric measurements, but it does not seem possible that they can be an underestimate.

On April 8 Titan was watched in transit from $19^h\ 30^m$ until $20^h\ 25^m$ G.M.T., at which latter time the altitude of Saturn was reduced to about 20°. The satellite was conspicuously visible as a dark disk at 0.7 way from the belt towards the north pole. It transited the central meridian at the computed time $20^h.0$. Its size was twice measured as 0″.30, but since a magnification of 660 was used, this result requires an added correction of about 0″.10 in order to be comparable to the values given in the table, which are believed to be correct as they stand. We were much disappointed not to see the shadow of the satellite, which in the case of Jupiter is always much more conspicuous than the satellite itself. Since the duration of its transit is given in the ephemeris as $1^h.5$ longer than the transit of the satellite, and since the sun on this date lay practically in the plane of the planet's equator, we believe the ephemeris to have been incorrect (Journ. B.A.A. 1920, **31**, 119). According to it the shadow should have appeared at $19^h.7$.

Mandeville, Jamaica, B. W. I., April 18, 1921.

THE GRAPHICAL REPRESENTATION OF GIANT AND DWARF STARS.

By HARLAN TRUE STETSON.

The accompanying diagram represents the number of stars of a given range of absolute magnitudes and spectral type, and is based

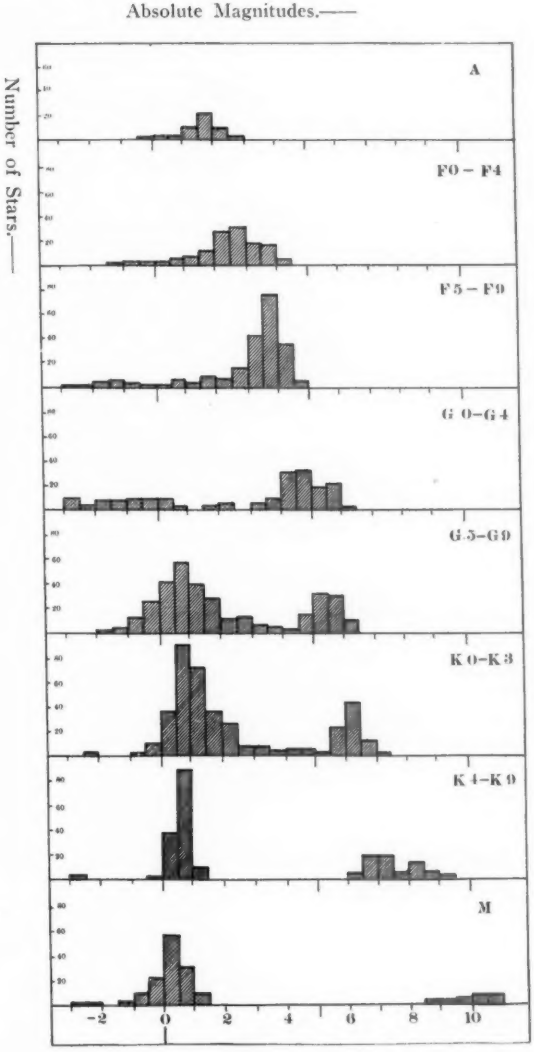

Diagram to Show Number of Stars of Given Absolute Magnitude by Spectral Classes.

on the published list of 1643 stars whose spectroscopic parallaxes have been well determined at the Mount Wilson Observatory.* This graph has been used in astrophysical study with classes of students at Harvard, and, it is thought, may prove of interest to readers of POPULAR ASTRONOMY.

The scheme is at once recognized as one much used in graphical statistics, and perhaps has certain advantages over the reversed "figure seven" diagram so effectively used by Russell in establishing the giant and dwarf theory. The scale of absolute magnitudes (the absolute magnitude being the apparent magnitude of a star seen at a distance of 10 parsecs) is laid off horizontally in the several cases corresponding to the different spectral classes. For the sake of mutual comparison between these several spectral classes, the several graphs are all arranged in a vertical sequence with the same Y axis denoting the zero of absolute magnitude. The height of any individual "block" in a given class represents the number of stars included in the Mount Wilson list which fall into a range of one-half an absolute magnitude, represented by the breadth of the same "block"; e. g., the highest block in class A represents a total of *twenty* stars which lie between absolute magnitude 1.5 and 2.0. The numerical data from which the graph was drawn has for the most part been published in POPULAR ASTRONOMY (loc. cit.) by Adams and Joy, and is not repeated. It has seemed wise, however, to subdivide spectral types F and G by recourse to the original list, and thus gain further knowledge of the intermediate steps.

For class work a wall chart may be conveniently made by cutting "blocks" of required length from strips of paper which may be procured gummed and in rolls of various colors. Such rolls are used by artists and commonly sold for "passe partout" binding for photographs. If the colors are chosen appropriate to the several spectral types, a very satisfactory wall chart will result and will prove instructive. Furthermore, as additional data come in, the chart may be easily kept up to date by gumming on additional lengths as occasion requires.

From a glance at the chart, several deductions are at once apparent, some of which are undoubtedly influenced by the way in which the data are procured; and some of which show without much doubt physical conditions in the stars. Other conclusions may be drawn which may be in question for some time, till we are able to gather more data and decide whether the results actually represent physical relations or are influenced wholly or in part by systematic error in the statistical material.

First of all, in regard to the total number in each group, we at once observe the paucity of A type stars represented. This is due to the fact that there is as yet scanty material for the group, since it is only

*Astrophysical Journal, **53**, 13-94. See Report of Twenty-fifth Meeting, American Astronomical Society, POPULAR ASTRONOMY **29**, 141.

recently that a satisfactory method has been evolved for determining the spectroscopic parallaxes of the so-called "early" (old style) or "bluer" (new style) type stars.

In a similar way, the proportionate number of dwarfs among the very red stars is undoubtedly small, due to difficulty of photographing faint red stars. Furthermore, owing to the low penetration of feeble short waves into the photographic emulsions, as has been recently pointed out by Ross,* it is quite possible that many faint stars appear redder than they actually are, and so give rise to an artificial paucity of blue stars.

The most striking and vital deduction from the graph is the bunching of the stars of G, K, and M types into two well defined groups of absolute magnitude. These two groups within the same spectral class represent on the one hand stars of absolute magnitude around 0 to 1, and on the other hand stars whose absolute magnitude ranges from 5-10. Such groups show complete separation in spectral classes K4-9, and M.

An examination of the figure shows that whereas the first group comprising the "giant" stars, so-called because of their unquestionable large size with enormous radiating surface, show a maximum around 0-1 in the last four classes, the second or "dwarf" group show that the maximum consistently shifts from about absolute magnitude 5.5 in type G to 10.5 in class M. This was also well shown in the characteristic figure used by Russell and printed in this Journal in 1914. On the basis of the Russell theory, we should expect the dwarfs to merge with the giants in the "earlier" spectral types. This merging is indicated in K0-3, and is clearly evident in G. Classes A and F hardly indicate more than a single maximum.

A careful comparison furthermore reveals that the giant stars of classes F appear to be meagerly represented. The high maximum occurs at absolute magnitude 3.5-4.0 in F5-9, and at absolute magnitude 2.5 to 3 in F0-4. This looks very much like the dwarf maximum clearly defined in the "later" types and through continued recession toward the Y axis appearing successively at absolute magnitude 3.5-4.0 and 2.5-3.0. In type A the maximum has arrived at absolute magnitude 1.5-2. In the vertical belt comprising absolute magnitudes 0-2 we find the greater part of all the giants, and yet in class F the number of stars within these limits is comparatively small. If there has been no systematic error in the selection of data, then it would appear that the small number of real giants in classes F must be due either to the comparatively brief duration of the "F" stages in the early half of the evolutionary period M K F A B A F K M or, what seems more likely, that comparatively few stars are massive enough to attain the F (giant) stage.

According to Russell's hypothesis of stellar evolution, we picture

*Astrophysical Journal, **52**, 86, Sept. 1920.

giant stars of enormous size (e. g., Betelgeuse) of extremely low density contracting under their own gravitation and, by virtue of Lane's paradox, gaining in temperature and surface brightness. With each gain in temperature the radiation maximum will continually shift to light of shorter wave lengths and the star pass successively through the spectral series M K G F A B and supposedly, according to Russell, remain of about the same absolute magnitude throughout, since the increased radiating power offsets the diminishing surface area. This will continue until the density of the interior becomes so great that Lane's law no longer applies, when the star slowly commences to cool and again retraces the spectral types in inverse order A F G K M, continually shrinking and of the dwarf stage. Since, as has been pointed out, the maximum temperature available depends upon the mass of an individual star, there will be many stars which never arrive at the "whiter" stages A B, but must pass from the giant to dwarf stage at an earlier place in the evolutionary scale. This would seem to be well borne out by a study of the graph. In fact, we should judge that many stars must pass from the G giant to the F dwarf stage and thence retreat down the dwarf branch back to M. Otherwise, the preponderance of dwarfs among the F classes could be accounted for perhaps by supposing that, owing to internal physical conditions, the "giants" pass very quickly through the F giant stages and linger longer in the F dwarf stage, which is not an unreasonable assumption.

The very remarkable and nearly linear relation between absolute magnitude and spectral type of the dwarfs may be seen by drawing an oblique line intersecting the several X axes at points corresponding to the absolute magnitude of the several dwarf maxima.

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THE GLACIAL PERIOD AND DRAYSON'S HYPOTHESIS.

By JOHN MILLIS.

The Drayson hypothesis to account for periods in the earth's history when a large part of the surface, in the present temperate as well as in the polar zones, was covered by a continuous ice sheet of great thickness, rests upon certain facts of astronomy connected with the positions and movements of the earth in relation to the sun, and these may be made clear by a simple diagram. Even the best informed will often welcome a very simple and elementary explanation that leads to an easier comprehension and a clearer grasp of any natural phenomenon of special interest.

Following a mode of representation common in the text books on astronomy, draw a circle to represent a section through the celestial

sphere, or the imaginary sphere of the sky, with the sun as the center. A circle at right angles to this with the same center represents the plane of the earth's orbit about the sun, the ecliptic, and another circle inclined to this second one is the celestial equator, in the plane of the earth's equator. The points where a straight line through the center and at right angles to the plane of the ecliptic meets the first circle are the poles of the ecliptic, and the poles of the equator are similarly determined. By assuming the celestial sphere to be of vast dimensions relative to the diameter of the earth's orbit about the sun, the axis of the earth—if it is regarded always to maintain practically an unchanging angular inclination to the plane of its orbit—will always seem to point to the poles of the equator on the celestial sphere. We are all familiar with the fact that the north star, which is very near to the

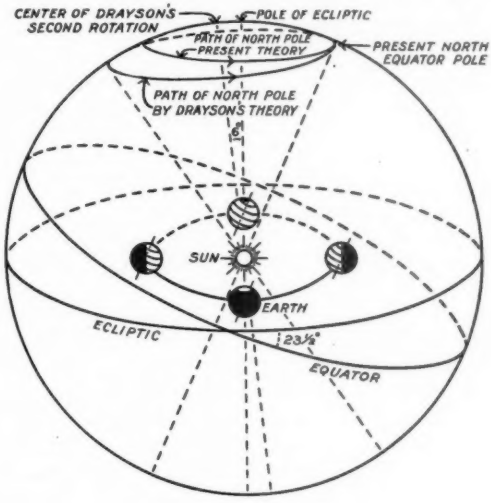

Fig. 1

north equatorial pole, has a seemingly fixed position in the sky day and night and at all times of the year, while the various constellations or groups of the stars apparently have positions for each month which are practically the same year after year. We also know that the zones on the surface of the earth, and the varying climatic conditions peculiar to each, are determined by the inclination of the earth's axis to the plane of the ecliptic, which determines relations to the sun's rays of heat and light. If this axis for example were always at right angles to this plane there would be no variation in the height of the sun above the horizon at noon and no change of seasons from summer to winter. The diameter of the polar zones within which the sun disappears entirely during portions of each year and is visible through the entire 24 hours at other times, the width of the torrid zone within which the sun

is directly overhead at some time during each year, as well as the width of the intervening temperate zones, are all determined by this angle, at present about 23½ degrees, as the diagram shows. While these conditions seem stable from year to year to the ordinary observer, it is known that they are subject to certain slow changes. The axis of the equator slowly revolves about that of the ecliptic, maintaining the intersection at the sun's center and so describing two conical surfaces having this center as a common apex. The result is that the north polar point, now very near to the pole star, is slowly moving. According to astronomical theory heretofore maintained the angle between the two axes above referred to, and hence the angle between the plane of the ecliptic and the plane of the equator, remains essentially constant, so that, while the intersection between the two circles slowly moves around as the equatorial plane "rocks" with the above movement, causing the "precession of the equinoxes," there is no material change in the present relation of the sun to the inclined position of the earth's axis and no change in the width of the respective zone areas and belts; therefore there will be no astronomical cause for any material variations in the regular annual changes of temperature and climate anywhere on the earth. Astronomers in general believe in this condition of practical stability as to the amount of the angular inclination of the earth's axis to the plane of its orbit about the sun, and mathematical demonstrations have been elaborated to prove that while the *position* of the angle in space can and does constantly change as described, any material change in its *amount* would transgress fundamental laws of celestial mechanics that govern the solar system and that such variation therefore is impossible. A minor secondary variation called "nutation" is not material to the present subject and will not be here discussed. The motion above described causes the polar points to describe circles on the celestial sphere among the stars, making a complete circuit according to present calculation in about 26,000 years. Therefore after half of this period elapses, 13,000 years from now, the north polar point will be on the opposite side of its circle from where it now is and 47 degrees away. It will then be not far from the bright star Vega and the north star Polaris will appear to be describing a daily circle around it with a 47 degree radius.

Now suppose the equatorial axis has an *eccentric* motion of revolution about the axis of the ecliptic, so that the north equatorial polar point traverses a circle about a center that is displaced to one side from the ecliptic pole. This evidently will mean a varying angle of inclination of the earth's axis to the plane of its solar orbit and a changing inclination relative to the sun, with corresponding variations in the widths of the zones on the earth's surface. The polar zones will gradually expand and contract in diameter, while the torrid zone will be concurrently widened and narrowed. The temperate zones at the same time will undergo reversed changes, becoming narrower as

the others expand and vice versa. The resulting effects on the earth's climate will be profound, and herein is the basis of the Drayson theory.

To locate the north polar points above referred to, start from the faint star in the Big Dipper which corresponds to the junction of the handle with the bowl, go directly to the pole star, then make a square turn to your left and go straight three-quarters of the distance first traversed. You will then be near the polar point of the ecliptic. Then go on in the same direction the other quarter of the first distance, and you will be near Drayson's center of the "second rotation."

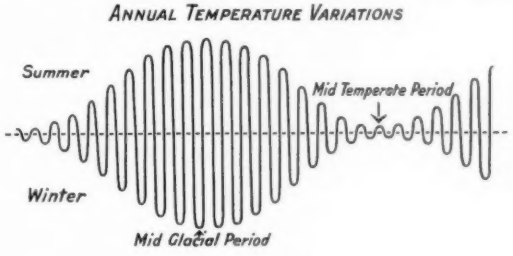

Fig. 2

Divested of the circles and axial lines and polar points, which are of course merely illustrative, the foregoing simply means a slow rocking or oscillating motion of the earth with respect to the sun as it revolves about the latter and turns on its own axis, so as to produce the effects described.

The fact of a glacial period in comparatively recent times (according to the scale of geology) during which the surface of the land, at least in northern latitudes was covered continuously by a sheet of ice of great thickness, extending down from the polar regions into the temperate zone, has long been generally accepted by scientific men as established by very numerous surface evidences that are found in both eastern and western hemispheres. The extreme limits to which the ice sheet extended were quite irregular and in places these limits are more or less indefinitely determined as yet, but on the North American continent the southern boundary of the glaciated area may be roughly described as starting in on the Atlantic seaboard a short distance south of New York, passing through northern New Jersey and northern Pennsylvania, following approximately a line determined by the Ohio and Missouri Rivers and passing westward to the southern part of the state of Oregon and on to the Pacific. The British Islands were almost entirely covered by ice and the glacial ice boundary in continental Europe can be traced through the central portion, but it is unnecessary here to follow its location in detail. The present surface features which permit these boundaries to be located would not strike the ordinary observer as determining any great difference in the gen-

eral appearance of the landscape just north of the limiting line from what is ordinarily seen in the regions immediately south of it, but to the glacial student the evidences are generally unmistakable. Throughout the marginal region that was covered by the ice sheet the most generally distributed surface indications are displayed by the nature of the material now spread over the country, which consists very largely of gravel, boulders or worn and rounded stones, sand and clay, generally laid down in a confused and unstratified mixture, and which often takes the form of peculiar hillocks, hollows, and ridges of a considerable variety of contour. Farther north (in the northern hemisphere) are found extensive areas where the ledge rock is exposed at the surface, and this often has the appearance of having formerly been swept clean of all fragments and loose material, while its surface is frequently seen to be scratched and scored or grooved and channelled as if by the movement over it of something hard and under great pressure. In addition very many evidences exist that show beyond question that much of the surface material above referred to must have been transported to its present location from regions farther north by some agency that was in action for a long period, and some of this material has been moved for hundreds of miles. These various glacial evidences pertaining to former times can also be checked with similar features near the margins of existing glaciers, particularly in Alaska, in Greenland, and in the Alps mountains.

The areas of former glacial actions now include those of the densest human population and the highest developments of civilization both in Europe and in America, and there is a very direct and intimate connection between the effects of the latest glacial period and the present interests and requirements of the human race. Among these interests are questions of topography and surface structure which determine water supply, drainage, and transportation, both by land and by water; effects on the soil which determine forest and timber resources, as well as all other vegetation; especially the subject of food production in general and of material for clothing, of general living conditions, and even that of mineral resources in an important degree This indicates the very pronounced concern for humanity which attaches to the entire subject.

The causes of such a remarkable difference between the climatic conditions now and those that must have prevailed when so large a portion of the earth's surface was continually covered by an ice mantle of great thickness, has long been a mystery and the subject of numerous and voluminous speculations and profound study. The several theories that have been advanced can not be gone into here in detail and it must suffice merely to mention two or three that have been most discussed.

Many years ago a British scientist, James Croll, proposed to account for a glacial period on the theory that the shape of the earth's orbit

about the sun is variable, taking periodically the form of an elongated ellipse and then returning to a more nearly circular shape, with the result that the northern and southern hemispheres pass through long periods, alternately, when the summer seasons occur as the earth is far removed from the sun and the mean annual temperature is therefore lowered so as to bring on glacial conditions. This theory calls for alternating glaciation in the northern and southern latitudes respectively but this has not been found to be entirely consistent with certain evidences that are now available. Other explanations that have been formulated are a periodic increase in the amount of carbonic acid gas in the earth's atmosphere, which would cut off a portion of the sun's heat and lower the mean temperature; extensive volcanic eruptions filling the atmosphere with dust that would have similar effects; changes in the elevation of portions of the earth's crust which would affect temperature, precipitation, and accumulation of ice and snow; and periodic disturbances in the sun itself which would disturb weather conditions on the earth. To all of these there are various objections which have not yet been satisfactorily explained away.

Here it will be appropriate to remark that there has been a quite general and an entirely natural assumption, even by many close students of the subject, that a glacial period must have been a long time of very much lower mean temperature than obtains at present, during which the ice sheet slowly accumulated or advanced over the surface of the continents from the polar regions and that then, with slowly rising temperatures, the ice gradually receded. In the details however it has been conceded that there must have been many variations in this general program; that there were several distinct partial "invasions," or repeated advances with retreats or recessions, which often left in places quite complicated evidences for which there has been no very satisfactory interpretation. But it will be clear upon reflection that the progressive accumulation of ice and snow, and the growth of an ice cover, only requires us to postulate winter conditions of precipitation and freezing that will be annually in excess of the effects of the summer melting and run-off, and that the mean annual temperature during glaciation might therefore have been little if any lower than it is now in temperate climates.

Alfred Wilkes Drayson (Major General, Royal Artillery of Great Britain) was for fifteen years a professor in the Royal Military Academy of Woolwich and was for two years attached to the Royal Observatory at Greenwich, near London. He died in 1901. His first published papers on what he called a discovery of "the second rotation of the earth" appeared about fifty years ago, and the Drayson hypothesis to explain glacial periods on the earth is founded on this "second rotation." This, be it noted, is a somewhat unfortunate and confusing designation and Drayson's reason for adopting it is not very clear.

It will be understood that great difficulties are involved in determin-

ing the exact path among the stars which the prolongation of the earth's axis traverses in the sky, or on the "celestial sphere" as the astronomers express it. At present this axis points so near to the pole star, or Polaris, that to ordinary observers this star appears to be constantly fixed in the sky at all hours throughout the entire year, while the Big Dipper, Cassiopeia, and other well known constellations and stars seem to revolve around it every 24 hours. The determination

Mean Obliquity of the Ecliptic on January 1st.

Calculated for the first 25 Centuries of the Christian Era on General Drayson's System of the Second Rotation of the Pole.

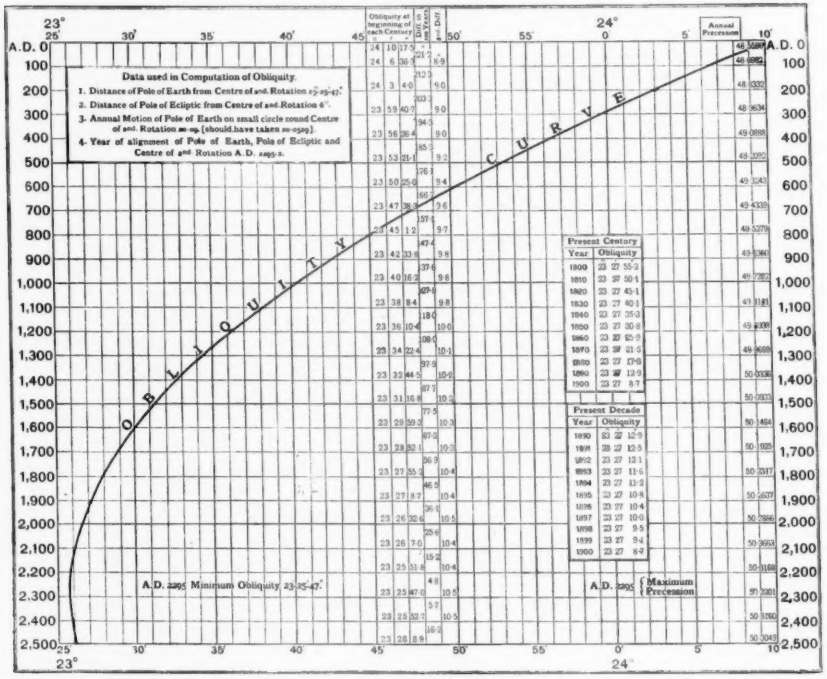
Data used in Computation of Obliquity.
1. Distance of Pole of Earth from Centre of 2nd. Rotation 23°-25'-47".
2. Distance of Pole of Ecliptic from Centre of 2nd. Rotation 6°.
3. Annual Motion of Pole of Earth on small circle round Centre of 2nd. Rotation = 0".0529 [should have taken = 0".0529].
4. Year of alignment of Pole of Earth, Pole of Ecliptic and Centre of 2nd Rotation A.D. 2295.2.
OBLIQUITY CURVE
A.D. 2295 Minimum Obliquity 23-25-47.
A.D. 2295 Maximum Precession
Present Century
Present Decade
A.D. 0
A.D. 2500

Fig. 3

From the book "Draysonia" published by Longman's, Green and Co.

of any change in the position of the polar point must be effected by observations on neighboring stars, and it is clear that the apparent daily revolution of these stars about the actual polar point will be affected by any change in the position of this point. The change of the polar point that is going on is so very slow that reliable observations and records for a very long period of years would be necessary to determine its path accurately, and naturally the farther back into the

past the records of observations extend the less numerous and the less reliable they become. Astronomical science has covered as yet only a very small portion of the 26,000 years that are required to complete the entire circuit of the path the polar point is assumed to follow under present accepted calculation and the chances of error as to the exact position of the center of the complete circular path as determined by direct observation is therefore very great.

By prolonged study of available records and laborious calculations General Drayson concluded that the polar point is not following a circle whose center is on the axis of the ecliptic or earth's path about the sun, as orthodox astronomical principles declare, but he maintained that the polar point actually traverses a circle whose center is displaced about six degrees to one side of the pole of the ecliptic and that the entire circuit around this circle is completed in about 32,000 years instead of 26,000.

Drayson's hypothesis has not yet been accepted by astronomers of the regular school as conclusively established even in principle, and it can not be said that glacialists generally concede that his deductions respecting a glacial period would all be sound, even if the theory proves to be astronomically correct, but it is not the intention here to go into these controversies. For present purposes the main point of interest is the striking *plausibility* of the theory as attested by very many glacial evidences, conceding that Drayson's estimate of time may be largely in error and even that there may be other influences, superposed upon or complicated with those postulated by Drayson, that interfere with the entire regularity of his deduced periods.

The direct consequence of Drayson's socalled discovery of most interest for present purposes is that the extent of the apparent traverse of the sun back and forth across the equator and over the tropical belt of the earth, and the diameter of the polar areas within which the sun remains below the horizon more than 24 hours during some portion of the year, instead of being practically constant and fixed for all time as astronomers now claim are in reality continually changing. The total of such variation, which it will be understood means a variation in the position of both the tropical and arctic circles, is about 12 degrees of latitude, or twice the six degree displacement above referred to. To illustrate more definitely, the Tropic of Cancer is now about 23½ degrees north latitude, and in the North American continent it passes just to the north of Havana, Cuba, and near the southern point of the peninsula of Lower California. The extreme southern position it can reach according to Drayson is 23° 25′ 47″, and the extreme northern position will be 35° 25′ 47″, which is near to Cape Hatteras, Memphis, Tenn., Oklahoma, and Santa Fe, New Mexico, and about midway between Los Angeles and San Francisco. The Arctic Circle must undergo variations in position which are the same in amount but opposite in direction to those that affect the Tropic of

The Obliquity Curve During a Cycle of 31,756 Years.

Showing the commencement, duration, and termination of last Glacial Period.

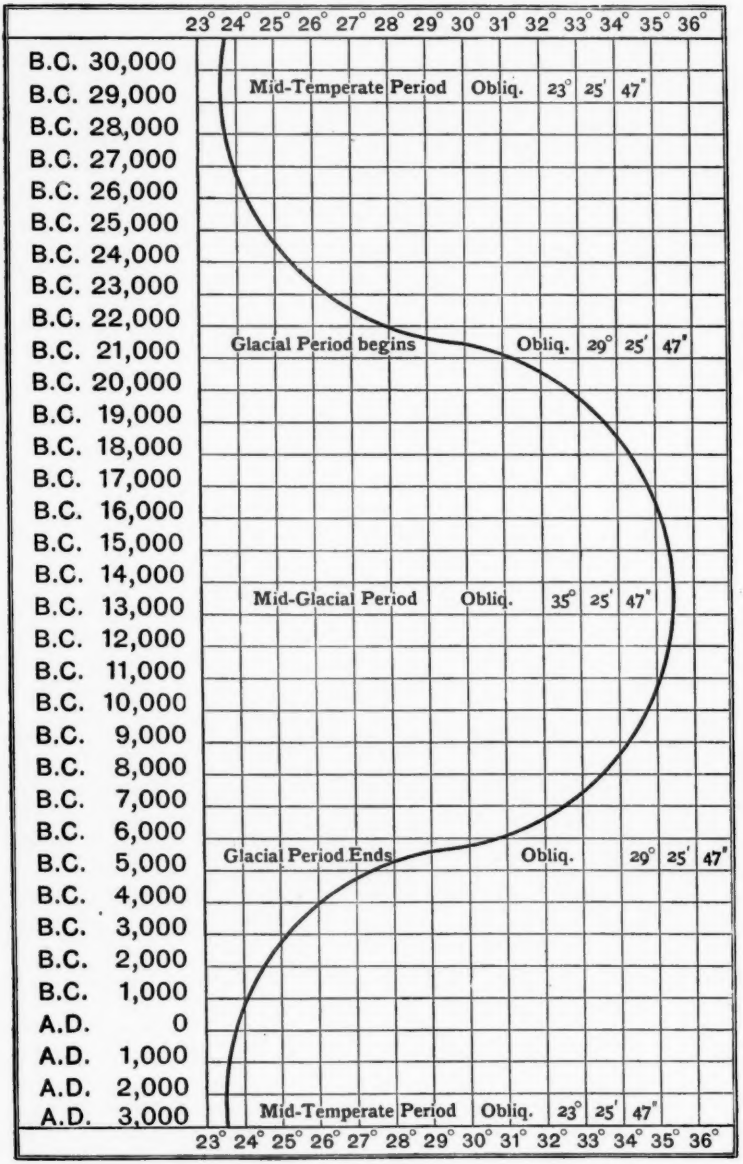

Fig. 4

From the book "Draysonia" published by Longman's Green and Co.

PLATE XXVII.

Laminated Clay and Sand, Wampter's Lake,
Jackson County, Michigan, May, 1921.

Laminated Clay and Sand, Wampter's Lake,
Jackson County, Michigan, May, 1921.

Cancer. Thus when the Tropic of Cancer is at its extreme northern position the Arctic Circle is farthest south, at latitude 54° 34′ 13″ (not far from "fifty-four forty"). It will then pass near the extreme southern limit of Alaska and a little south of the southern shore of Hudson Bay. Similar variations must take place concordantly in the southern hemisphere, with the net result that the tropical belt and the polar areas expand and contract synchronously, while both the temperate zones contract and expand in opposite phases.

The complete cycle of Drayson, which may be taken at about 32,000 years' duration, although the estimates seem to have varied slightly, obviously from its causes could embody no "jumps" or abrupt changes. It may be likened somewhat to the changes of the seasons throughout the year, in which we recognize the rapid shortening of the days and lengthening of the nights in the fall, the steady cold of the midwinter season of short days and long nights, the increasing length of days and shortening of the nights with the disappearance of snow and ice and coming of warm weather during the spring season, and the settled heat of summer with its short nights and long days. So, in the curve Drayson draws to show the changes in the angular distance of the pole of the earth from the ecliptic pole throughout the cycle of about 32,000 years, we can make four divisions, each merging gradually into the others as the seasons of the year do. These are, first a period of somewhat rapid increase in the above angular distance, with corresponding shifting of the polar and tropical circles and narrowing of the temperate zones, lasting nearly 8,000 years; then a period of similar duration which is one of comparative stability and which comprises the climax of the glacial period. Following this comes 8,000 years again of comparatively rapid change, this time towards the *minimum* angular displacement, the broadest temperate belts, and the most limited tropical zone and polar areas; and then 8,000 years of relative stability which includes the "mid-temperate" period. If we compare this complete period to a single year, we are now at the point in it corresponding to about four days before midsummer, but in reality it will still be 375 years before we actually reach the mid-temperate point, and then of course it will be 375 years more, or 750 years from the present date, before we reach again the point where we now are in the glacial cycle. The Arctic Circle has still to move only about a mile and a half north, and the Tropic of Cancer the same distance south, before we will be at the mid-temperate point, in the year A. D. 2295. The total movement of these circles since the beginning of the Christian era has been about 1° 8′ or 78 miles. Drayson's theory places the last mid-glacial period about 15,000 years ago, but of course the beginning and termination of that period were indefinite, since this would depend on the location on the earth that is under consideration.

The effects on the climate of the earth must have been very marked under the changes above outlined, but these effects were not necessar-

ily, and probably were not in fact, a general lowering of mean temperature all over the world. It was doubtless rather a slow and regular progressive increase in the *variations* or extreme oscillations of the temperature during each year as the maximum point of the glacial period approached, with gradual return to present conditions; in other words greater annual extremes of both heat and cold, with the changes of temperature between summer heat and winter cold of each year greatest in amount and most rapid in rate at the mid-glacial period and least at the mid-temperate period, while the mean annual temperature or the average for the whole year may have been about what it is now. One consequence of such extreme annual variations would have been great atmospheric disturbances, resulting in the prevalence of high winds and severe storms, a greater evaporation of water on the seas in higher latitudes, and a very greatly increased precipitation in the form of rain and snow on the land. The snow and ice thus formed would melt and run off copiously during the hot summers, but gradually, as the initial point in a glacial period was approached, the accumulations of winter would overtake and pass the waste during the summer and the formation of the general ice sheet would begin, and this would gradually grow and creep over the land from the regions of higher latitudes. During the mid-glacial period the ice conditions remained practically stationary or in general equilibrium for a long time, with the melting and waste during the hot summers just balancing the precipitation and freezing and accumulation during the extreme cold winters, though the general creep of the ice toward lower latitudes still continued. Then the waste of summer began to gain on the accumulation of winter and the shrinkage of the ice sheet began in both thickness and horizontal extent, while its bodily movement towards low latitudes slowed up and practically ceased before it finally disappeared from any particular locality by melting. This wasting process reached its culmination at what Drayson calls the mid-temperate period, the last one of which he places about 29,000 to 30,000 B. C., while we are now relatively very near to the next one.

Conceding that the above was the progress of events in broad outline, there are many evidences which show that we must admit numerous variations of detail in the general program, comparable to the departures from perfect regularity in the seasonal changes which we now observe from year to year. We have a late fall, a severe or a mild winter, an early spring, a hot summer, etc., not to mention unusual floods and droughts and widespread storms and hurricanes that are markedly variable from one year to another. Likewise in the progress of the long glacial cycle there seem to have been halts and backward steps and readvances of the ice mantle, and perhaps other variations from a completely well ordered schedule, but it must be admitted that the evidences of several rather distinct glacial invasions during the pleistocene are not as yet reconcilable with the Drayson theory. It is

however, a little remarkable that a theory so interesting and plausible should have become almost forgotten until attention was called to it by an article by Major R. E. Marrott, in "Science Progress" for April, 1919. This was suggested apparently by observations in the Antarctic continent which strongly indicated that a glacial period was concurrent for the northern and southern hemispheres, instead of being alernate as called for by the Croll theory. Even after this notice the Drayson theory has seemed to remain practically unknown and its significance quite unrecognized by our most distinguished students and investigators in the field of glacial geology. Possibly this is attributable in part to overlooking certain rather striking instances of the direct bearing of the dormant theory on certain glacial phenomena that have been more or less in controversy among experts, and so far as known these have not been pointed out in this connection heretofore. No doubt others have entertained views similar to those expressed in the following quotation from an article by the present writer published in *Science* of February 6, 1914, pp. 209:

"I believe that the seasonal variations in temperature that must have occurred even during the low average temperature of the glacial period, with resulting changes in the internal structure and movements of the ice, constituted an influence of more importance in connection with general glacial phenomena than has heretofore been recognized."

In this article the theory of the formation of the *eskers* referred to later in this paper was first proposed.

At that time the author had not heard of the Drayson theory but this now seems to open the way to a solution of several glacial mysteries.

First, the general bodily creep or movement of the ice sheet towards the equator, of which there is conclusive evidence, as in the boulders and rock material that have been transported long distances and in scratches and scorings left on surfaces of rock in vast areas over which the ice sheet lay. The physical reasons for this general movement of the ice have been extensively speculated about and probably the most generally accepted theory is that with increase in thickness the ice gradually yielded under the influence of gravity and naturally moved in the direction of least resistance, while the movement was sustained by the weight of continuing accumulations in high latitudes. This is not altogether satisfactory under the simple hypothesis of a regularly accumulating mantle of ice, but when excessive temperature changes during each year are recognized the problem appears much easier. This would produce alternate shrinking and cracking of the ice, melting and accumulation of water in fissures, and then freezing up again with expansion and a general pushing forward. If this action was sufficiently intense and general and repeated every year over a

very long period of time, it assists greatly in understanding the creep of the ice mantle towards lower latitudes.

A steady growth of the ice sheet and its equally regular wasting away and recession, even if the complete cycle should require scores of thousands of years, is not quite satisfying as accounting for the vast amount of widely strewn debris in the way of an extensive mantle of glacial waste or "till" material, in places hundreds of feet thick and frequently with more conspicuous accumulations in the shape of morainic hills and drumlins, kames, esker ridges, and the many variations of these forms. Such a gigantic grist of boulders, gravel, sand, and clay suggests an enormous "mill" on a commensurate scale, not only as to dimensions, but a mill that must have been tremendously active for a very long period. No attempt at any definite quantity calculation is possible, but the Drayson theory with its long continued and extreme annual see-saw of temperature, and the resulting surge and grinding action, appeals strongly to a sort of general sense of the consistency of things regarding the forces and actions that must have been involved in producing the immense and widespread glacial products.

The evidences of a large and prolonged flow of water over areas where the till has been left, at some period in the past and subsequent to the time when glaciated areas were covered with ice, are very numerous and very generally distributed, especially within the marginal areas occupied by the ice sheet in its more advanced positions. These take the form of eroded waterways or channels now abandoned, or of wide and well defined troughs through the bottoms of which streams and even large rivers now meander, but which could not possibly have been formed by any erosive action of these streams with their present volumes of flow, even taking account of modern flood conditions. A striking example of this is the upper Mississippi, which for many miles shows a clearly defined trough often two or three miles wide through the bottom of which the present river winds back and forth but which it never completely fills. Very many of the smaller streams of the glaciated areas also follow similar troughs. Other examples are the channels that formerly carried outlet streams from certain portions of the Great Lakes; the Chicago outlet channel, now followed by the sanitary canal; the channel in Michigan followed by Grand river; the Fort Wayne, Indiana, outlet channel; the Mohawk channel beginning near Little Falls, N. Y., etc. A long period of regular winter accumulation and summer melting and voluminous run-off accounts better for these features than does merely the run-off that would result from a regular progressive wasting of the ice during the waning stages of the glacial period. The theory may also help to account for the preglacial channels now filled with glacial till and obliterated, that have been discovered in certain localities by borings for wells.

In many localities are found extensive deposits of laminated glacial clay often many feet in thickness—a hundred or more. The following may be mentioned: Along the lower Hudson River, where several of these deposits are extensively mined and the material is used in the large brick making establishments; along the Connecticut River; in several places in the Great Lakes region; and notably in Sweden, where special studies have been made and where the real significance of these deposits seems to have been first systematically worked out. These deposits consist of thousands of horizontal layers of clay generally a fraction of an inch in thickness with thinner interspersed layers of fine sand, which in general approximate to uniformity in individual thickness, although there is more or less variation in this respect. The deposits were very probably formed by the annual melting of ice during the summer seasons throughout a glacial period of thousands of years and the transportation of the finer particles of earthy material to quiet ponded waters where the suspended material slowly settled. The sandy layers which separate those of clay quite regularly were probably caused by the first rush of water during each spring season. Wind blown dust and sand may also have had something to do with these deposits.

In certain mountainous regions vast hollows or amphitheaters called "cirques" excavated in the sides of the rock slopes apparently by glacial action have been the subject of much discussion and considerable controversy. Some regions seem to have been so extensively sculptured by this cause as to give characteristic forms to entire ranges and groups of mountains. The process has been called the "plucking" action of glaciers in breaking and removing the shattered rock, though this has been questioned, but the long continued and intense annual temperature variations of the Drayson theory, with the freezing and thawing and resulting flood action and the "gnawing" and mechanical effects, make this whole process and its results much clearer.

Another long standing mystery of the glacial period is the *eskers*—ridges composed generally of confused mixtures of boulders, gravel and sand often miles in length with a fairly direct alignment; steep sided, and with an approach to uniformity of height, that are found in various localities, generally near the extreme limits reached by the ice sheet and within the former limiting border. While these ridges pertain as a rule to reasonably level areas, instances are found where they cross hills and valleys. They vary in height up to fifty or seventy-five feet and they often have the general appearance of a railway embankment. The Drayson theory helps out quite strikingly in explaining these curious formations. It can be said quite confidently that the eskers are simply the result of great cracks or fissures opened in the ice sheet during the waning period, when the ice was thinned and generally stagnant, and they were formed by the annual local shove and surge due to temperature changes, the breaking at the

edges, the periodic summer melting of the fragments, and the localized deposit of the coarser portions of the englacial material which was shoved up into a sharp ridge, while the scooping or excavating effect of the edges and fragments of the broken ice produced the trough or valley along the axis of which some eskers are located. The washing or leaching effect of the water during melting, the draining off of which was generally favored by local conditions, carried away the clay and fine sand of the till material leaving only the coarser constituents. In other words the eskers mark the location of long "expansion joints" in the thinned ice sheet when it was still under the influences of great annual changes of temperature. A similar action would account for many other surface formations that are found in glaciated areas, like multiple, irregular and short and interrupted eskers, the kames, and even some of the so-called terminal morainic ridges, knobs and hills. This also contributes to an understanding of one of the most conspicuous and widely distributed of all the topographic feaures of the glacial period—the terminal moraines. And there is ground for expectation that the problem of the *drumlins*, which still awaits an entirely satisfactory solution, may also be cleared up under the resurrected hypothesis.

Perhaps the following will be regarded as the most surprising suggestion as a possible incident of the glacial period under the theory in question. Could there have been during the fierce summer's heat of those times an annual period of extraordinary *drouth* with a minimum of precipitation, violent winds, and conditions which prevented vegetation from spreading over the land in the general vicinity of the border of the ice sheet which had been recently left bare by its recession? Under such conditions combined with exalted atmospheric disturbances it is not difficult to conceive that vast *dust storms* might have occurred. The deposits to great thickness of very fine, unstratified and apparently windborne, soil called *loess* over certain extensive areas within the Mississippi basin have been a considerable puzzle. These may be thus explainable by the above suggestion, and also the still more extenive deposits of this nature in Germany and more especially in China.

We generally speak of "the" glacial period, referring to the evidences of glaciation during the comparatively recent pleistocene times of geology. These are by far the most widespread and distinct indications of an ice period that are at present known on any part of the earth's surface, but it is now practically established that pleistocene glaciation consisted of a number of more or less distinct sub-periods, each probably representing many thousands of years. In addition, unmistakable evidences relatively meager to be sure, of ice ages in much earlier geological periods have been found in various parts of the world in all the continents. The deduction is obvious that glaciation has been a recurring phenomenon throughout geological history,

but we can not yet attempt to formulate the complete law that has governed its periodicity in the remote past.

Many estimates have been made of the period of time that has elapsed since the final disappearance of the ice of the latest glacial period in our latitudes. Some of these agree fairly well, but there have been several rather marked instances of inconsistent or discordant results. The rate of erosion of the rock formation in the gorge of the Niagara River, and the recession of the crest of the falls, as determined by actual observations during a considerable period of years in modern times, has been regarded as one of the most reliable means of calculating the time since the ice sheet uncovered the course of this river, but the result of the calculations based on these data, about 25,000 years, greatly exceeds another group of calculations which have assigned from 8,000 to 10,000 years as the total length of the same period. It is known that in glacial times the general level of the several lakes was higher than at present, and also that the level of the general surface of the earth in the basin of the great lakes has been subject to displacements varying in nature and degree in different localities. These changes must have affected the slope and discharge capacity of rivers and channels, and the melting of the ice with greater precipitation and corresponding greater runoff, would also have affected the volume of discharge in the Niagara River and rate of erosion of the rock and the recession of the falls. Thus the general effect, if the Drayson hypothesis is correct, would be that the rate of recession of the falls was greater in former times, and therefore the estimate of time that has been made based on the observed rate of recession during the later historic period is probably too great. This would tend to bring the actual period of time since the disappearance of the ice in the vicinity of Niagara Falls more nearly into accord with the shorter estimates above referred to and with Drayson's hypothesis.

It is rather significant that nearly all of the most remarkable known remains of prehistoric and ancient human cultivation and civilization of the higher types are found in or near to the tropical belt, and often in regions now unfitted by existing climatic conditions for residence and activity for the most progressive races of men. The following localities may be mentioned as examples: Farther India, Java, Ceylon, and Southern India, Egypt, Yucatan and Southern Mexico, Central America and Peru, and on certain islands of the Pacific. Practically no remains of importance of this character have been found in the higher latitudes where civilization now has its greatest development. In a measure this applies also to the more important monuments of the early Greek and Roman civilizations. The works of early mankind in Mesopotamia, Persia, Palestine, Chinese Turkestan, and in New Mexico and Arizona, are considerably removed from the tropic line, but they also indicate former races now extinct or decadent that reached a high state of development under climatic conditions which

must have been materially different from those that now obtain, though there may have been contributing causes other than those here referred to. This subject has been extensively discussed in the writings of Professor Ellsworth Huntington of Yale University.

And what do we see upon attempting to look into the far distant future? It must be confessed that it is rather sobering to reflect on the possibility—indeed the strong probability—that at some date in future, which we may be able to predict with reasonable certainty, a very large part of what we now regard as the highest achievements of human civilization in the most densely populated areas of both Europe and America will inevitably be overwhelmed, engulfed, swept away and completely destroyed by a repetition of glacial conditions, while even extensive areas outside those actually so invaded will become uninhabitable by man because of climatic changes. We can imagine the effects long before the climax, on extensively occupied and developed bottom land areas, that will follow the restoration of the Mississippi and other rivers and streams and channels to their former volumes of flow. The drowning out of cities like Duluth, Chicago, Cleveland, Toledo and Detroit, all of which occupy sites formerly submerged at the higher lake levels of glacial times, would also precede the actual arrival of the glacial cover in their respective localities. According to Drayson the coming glacial period will culminate in the year *eighteen thousand three hundred and forty*, of the Christian Era.

Of course this estimate must be regarded at present with considerable reservations, but there seems little room to question that glacial conditions have been recurring and periodic for a long time in the past, and it would be quite illogical to assume that nature will radically change her program and adjust herself in future to the needs or desires of a race of beings that have so recently come upon the stage. It may not be beyond the bounds of possibility to develop a new and rather startling logical and scientific *reality* to replace the more or less crude and mythical legends, superstitions, and speculations regarding a great cataclysm in the remote past and something of the kind expected in the distant future that have taken various forms—generally of vast inundations or conflagrations—in the minds of men of various races since the earliest known existence of the intelligent human family. Can it be that collective humanity with all of its strifes and struggles, its successes and failures, its accomplishments in great works and structures, in science, art, literature, and general civilization; its wars and crimes and unmoral acts and proclivities, its altruistic creeds and its lofty ethical and religious faiths, its exalted ideals and ambitions as to its "destiny"—that *all this shall pass away;* shall prove to be a mere inconsequential and temporary incident of a single phase only in a great changing cycle which this world experiences over and over again through the ages. And this only *one* of a *minor class* of such cycles as is indicated by other geological and astro-

PLATE XXVIII.

GLACIAL TILL AND STRATIFIED SAND, ST. CLAIR COUNTY, MICHIGAN, BLACK RIVER, MAY, 1920.

ACKERSON ESKER, GRAVEL PIT, JACKSON COUNTY, MICHIGAN, MAY, 1920.

nomical evidences! Surely these reflections are not flattering to man's egotistical vanity, but it is a real accomplishment merely to get a comprehensive grasp of one's own very littleness and transitoriness. Upon serious contemplation of the present trend of certain developments of our most advanced civilization, who shall assert that a definite prospect that this is all to be relegated to the domain of prehistoric archaeology at some future date which can be accurately foretold, with an entirely fresh start and a primevally clear field, will be altogether without advantage or something unqualifiedly and unreservedly to be deplored?

May 17, 1921.

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TWENTY-SIXTH MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY.

(*Continued from page* 568.)

ABSTRACTS OF PAPERS.

THE PROBABLE ABSENCE OF A MEASURABLE ELECTRIC FIELD IN SUN-SPOTS.

BY GEORGE E. HALE.

Observation shows that a sun-spot is a vortex in which an intense magnetic field exists. If this field results from a proponderance of positive or negatively charged particles in the vortex, an electric field should be present. It is a question whether under solar conditions such a field could be sufficiently intense to produce visible effects, but an attempt has been made to settle this by observation. Three methods have been employed:

(1) A search in the sun-spot spectrum for the Stark effect, of which no indications have been found.

(2) The spectroscopic phenomena due to radiation in a combined magnetic and electric field may differ materially from the simple summation of the Zeeman and Stark effects, especially at certain angles between the lines of force. A study of the combined effect has accordingly been undertaken with the assistance of Mr. Sinclair

Smith. In the case of hydrogen the spectrum has been photographed in the Crookes dark space in front of the cathode of a special vacuum tube, where a strong electric field is present. The tube was placed within a coreless solenoid magnet, designed by Anderson to carry a current of 4000 amperes through coils of bare copper tape cooled by a rapid flow of kerosene. In the preliminary experiments, made with the lines of electric force parallel to those of magnetic force, the difference between the combined effect and the summation of the two effects is slight for $H\gamma$, but is apparently greater for some of the lines of the secondary spectrum. The work is being continued with the aid of special quartz tubes, designed for heavy discharges, but no results applicable to the spot spectrum have yet been obtained.

(3) The fact that the great majority of the enhanced lines in sun-spot spectra are weakened, while none are strengthened, shows that ionization is much less complete in spots than in the general solar atmosphere. This must mean that no electric field, sufficiently intense to overcome the reduction in ionization caused by the reduced temperature of the spot vapors, can be present. If the pressure in spots can be more accurately determined, and the ionization phenomena of mixed vapors elucidated by electric furnace experiments, it should be possible with the aid of Saha's ionization theory to estimate closely the maximum strength of any electric field that may be present in spots. From present indications, the strength of any such field must be decidedly below the intensity required to show an appreciable Stark effect in the spot spectrum.

It should be remembered that these negative results apply only to the vapors which constitute the umbra. It is conceivable that within the underlying spot vortex an electric field may exist, though no direct method of detecting it can be suggested.

MARS (1920).

By George Hall Hamilton.

The interest that has always attached to the planet Mars seems to be in no way abating—especially as at each succeeding opposition some new aspect of the planet is brought to our consideration; or else detail, that may have been familiar to us for many years, takes on a new significance.

In 1920 the northern hemisphere of Mars and part of the southern were presented to us and the Martian season corresponded to the month of August on earth—a season that has not been shown to us to full advantage for about fourteen years. We were enabled thus to study the surface of the planet under a summer sun, to follow the changes throughout this season and also those changes which were of daily occurrence upon the surface of the planet and in its atmosphere.

It appears that at this season on Mars atmospheric changes are at their maximum, and thus growth and change upon the surface can be detected to an unusual extent. The view one gets of the planet at this time can best be described by what occurs in the tropics after a summer rainstorm when everything is alive and young shoots are budding, the whole overlaid by a fine mist as the waters again rise at the bidding of the sun.

There were two regions on Mars where the surface markings were blurred and confused; but this was not due to our own atmosphere and the bad seeing that may ensue from that cause, but to the Martian atmosphere itself. These regions—the Syrtis Major and also that about the Lucus Lunae—were viewed to advantage but appeared through a denser atmosphere than usual on Mars which was attributable to evaporation and consequent mist.

The northern polar cap was at that time at its minimum and there was unwonted activity in the southern regions, oases and canals being visible there at latitudes too far south for that season of the year. Owing to the season the whole visible surface of the planet was undergoing an unusually hot period, which precluded a precipitation of moisture upon the poles, and the atmosphere itself had to sustain the surplus moisture. This was observed visually and photographically, for in the regions where evaporation was greatest clouds were observed as evening approached; forming as the atmosphere cooled at the setting of the sun and for an hour or two before, completely covering the surface features with a dull blue-white similar to that observed at the forming polar caps in autumn. Whether these clouds continued throughout the night it is impossible to say, but they were still visible or re-formed in the early morning and only dissipated some time after the rising of the sun.

THE SPECTROSCOPIC SYSTEM OF σ SCORPII.

By F. Henroteau.

The present study is based on the investigation of a considerable number of spectrograms taken in 1918 (Lick Observatory), and in 1920 and 1921 (Dominion Observatory). The principal results of the study are:

1. There is a short period radial velocity variation of constant amplitude, $P = 0^d.246834$. This period, however, has a tendency to decrease a little.

2. The mean velocity (or center of mass velocity) of each short period radial velocity curve is variable, indicating motion in an elliptic orbit with a period of $34^d.08$ and a rather large eccentricity, the elements of the orbit being, as published in the *Lick Observatory Bulletin:*

$$
\begin{aligned}
K &= 33\,\text{km} \\
e &= 0.33 \\
P &= 34^{d}.08 \\
\omega &= 270^{\circ} \\
T &= \text{J. D. } 2421715.35 \\
\gamma &= -3.2\,\text{km} \\
a \sin i &= 14{,}600{,}000\,\text{km} \\
\frac{m_1^3 \sin^3 i}{(m + m_1)^2} &= 0.107\,\odot
\end{aligned}
$$

3. The observations of 1920 and 1921 revealed striking changes in the last orbit, especially a large variation of the amplitude of the velocity curve. As the eccentricity, the period, as well as $a \sin i$ and the function of the masses, do not change much, the change af amplitude suggests tipping or rotating of the plane of the orbit, which could be explained on the assumption of strong perturbations.

4. Three hypotheses are suggested to explain the short period radial velocity curve. First, pulsation; but this has to be rejected, being unable to explain even very small perturbations. Second, rotation of a Jacobian ellipsoid (with strong darkening at the limb or very small nucleus) of mass about 12.5 and density 0.1 that of the sun. Third, a very short period binary system.

5. The perturbations have been computed, and the very flat rotating ellipsoid as computed by Darwin (immediately following the point of bifurcation between the MacLaurin's and the Jacobian ellipsoids) would perhaps explain the observations.

The complete study of the system will be published in the *Publications of the Dominion Observatory*.

SOME REMARKS ON CEPHEID VARIABLES.

By Frank C. Jordan.

A number of light curves of Cepheid variables have been published by Martin and Plummer of Dunsink Observatory. These show in every case secondary oscillations, and the observations are therefore subjected to harmonic analysis, using several terms, to fit the curve to the observations. Several of the same stars have been observed at Allegheny with the 30-inch Thaw refractor, using the extra-focal method. This method undoubtedly yields more accurate magnitudes than those given by the measurement of star diameters, yet the Allegheny curves do not show secondary oscillations. It is therefore probable that these supposed oscillations are the result of unavoidable errors in the observations, as the method of exposing the plates and making the measures would seem to allow latitude for such errors. Curves are shown of the same stars as obtained at the two observatories.

The somewhat prevalent idea that Cepheid variables do not follow

the same curve of variation at different epochs is not substantiated by our observations on these stars.

A REMARKABLE METEOR TRAIL.

By Frank C. Jordan.

On the morning of July 10, 1921, a meteor trail was obtained on a parallax plate exposed in the Thaw 30-inch refractor. Its whole recorded flight was only one degree and this was all included within the limits of the field of the telescope, 0.75 square degree. It was probably brighter than Venus, and must have been traveling nearly in a line toward the point of observation.

ON DESENSITIZING PLATES IN PARALLAX WORK.

By Frank C. Jordan and Keivin Burns.

To secure a greater range of magnitude reduction than is attainable with the ordinary rotating sector, the Allegheny Observatory is now desensitizing a central area of the photographic plate before exposure.

The method consists of the application of a one percent solution of copper sulphate for five minutes. This is then wiped off and the plate dried with a fan, at a temperature of 64° to 70° F.

The sensitiveness is reduced about fifty times; the grain of the plate remains unchanged, and tests indicate no reduction in accuracy.

APPROXIMATE ORBIT AND ABSOLUTE DIMENSIONS OF S ANTLIAE.

By Alfred H. Joy.

The classification of this well known southern variable star of short period has been much discussed since its discovery in 1888. The early observers placed it in the class of eclipsing binaries and the results of this paper would return it to that class. In 1896 Pickering found from meridian photometer measures that the light was continually changing and that the minima, which were of nearly equal depth, occupied a large fraction of the period. He therefore concluded that it could not be of the eclipsing type. It was later treated as a single rotating ellipsoid by Shapley and as a cluster type variable by Plummer.

The spectrum is of type A8 with two components of apparently the same type, one about twice as strong as the other. The lines are wide and diffuse making measurement exceedingly difficult. The velocity-curve shows that Luizet's period should be doubled and that the

changes may be accounted for by a star of the Algol type with little or no eccentricity.

A solution for the nineteen plates secured gave the following elements of the spectrographic orbit.

$$
\begin{aligned}
e &= 0 \text{ (assumed)} \\
K &= 81 \pm 2.5 \text{ km/sec.} \\
K_1 &= 148 \pm 11.6 \text{ km/sec.} \\
\gamma &= -5.0 \pm 1.8 \text{ km/sec.} \\
a \sin i &= 722{,}000 \text{ km} \\
a_1 \sin i &= 1{,}320{,}000 \text{ km} \\
m \sin^3 i &= 0.52 \odot \\
m_1 \sin^3 i &= 0.29 \odot
\end{aligned}
$$

The results of the spectrographic observations made it seem worth while to examine again the photometric measures. It was accordingly found from the study of the Harvard approximate light-curve that the variations could well be accounted for by supposing eclipses of two ellipsoidal bodies of nearly equal size and surface intensity. The elements are closely defined by the light intensity of the two stars as shown by the spectrum.

The photometric elements found are:

Period	P	0.64833872 days
Ratio of radii	k	= 0.775
Percentage of eclipse	α_0	= 0.36
Eccentricity of stars	e	= 0.66
Inclination of orbit	i	= 62° 10′
Ratio of surface brightness	J_b/J_t	= 1.2
Duration of eclipses		= 0.180 days each.

The computed curve satisfies the observations with sufficient accuracy.

By comparing with the spectroscopic elements we now derive the absolute dimensions.

Radius of primary orbit	1.17	Sun's radius
Radius of secondary orbit	2.14	" "
Distance of stars (centers)	3.31	" "
Semi-major axis larger star	1.66	" "
Semi-minor axis larger star	1.25	" "
Semi-major axis smaller star	1.29	" "
Semi-minor axis smaller star	0.96	" "
Distance of surfaces	0.36	" "
Magnitude at maximum	6.39	
Magnitude at primary minimum	6.83	
Magnitude at secondary minimum	6.79	
Mass of primary star	0.75	Sun
Mass of secondary star	0.42	"
Density larger primary star	0.31	"
Density smaller secondary star	0.38	"
Parallax (surface brightness = 4 sun)	0".016	

The difference in velocity at the limbs of the large star is 225 km/sec., which easily accounts for the character of the spectral lines.

No darkened solution was attempted but it was evident from inspection that the assumption of stars darkened at the limb would somewhat improve the fit of the computed curve.

The variable S Antliae is concluded to be an eclipsing system of two nearby, elongated stars, the larger, brighter and more massive star being partially eclipsed at primary minimum. The star would repay further accurate photometric observations.

SOME RECENT RESULTS IN PHOTOGRAPHIC PHOTOMETRY.

By Edward S. King.

Photovisual magnitudes for a list of 24 stars were given in *Harvard Annals* **81**, 4. During the last two years further measures of 44 stars have been made with the 8-inch Draper Telescope. The same color filter has been employed with Cramer Isochromatic plates, but the apparatus has been improved. Although the new apparatus permitted more accurate settings, yet it was found that even curvature of the plate, particularly for those positions nearest to focus, was sufficient to introduce slight errors. This was shown by experiments made by placing over the objective a grid of parallel wires arranged at intervals of 2 cm apart, and photographing out-of-focus images of a star at the different settings. From measures of such images it is possible to determine both the focal plane and the focal length of the objective. The focal length, thus found, is not that which determines the scale of chart plates. This difference in focus for the instrument used amounts to about two centimeters. In view of such errors, I am now using a cap over the lens, which has two wires parallel to each other and 16 cm apart. The distance between the images of these wires, as shown on the out-of-focus disks, is measured. The dimensions of each disk also are measured and corrected for diffraction. From all these measures the light-value for the image is found.

Although the work on this list of 44 stars is not complete, I have made a preliminary reduction. One of the results shows the relation of the photovisual magnitudes to the photometric magnitudes given in *Harvard Annals* **50**. Plotting differences, photovisual minus photometric, as ordinates, and spectral classes as abscissas, the difference, ranges from $+0.14$ magnitude for Class B to -0.12 magnitude for Class M. This shows that the color value of this photovisual system is slightly toward the red. Drawing a line to represent the plot, the change from B to M is about 0.18 magnitude. Moreover, to make the two systems agree for Class A, according to the convention established, we find from 11 stars of this class that about 0.16 magnitude must be subtracted from the photovisual values. If we take all the stars, as well as those of Class A, into consideration, the amount to be subtracted is only 0.06 magnitude. It is a question which result should be accepted.

Many measures for the photovisual and the photographic magnitudes of the bright planets have been made and are still in progress. Observations have been begun also at Arequipa for the photovisual magnitudes of a selected list of southern stars.

NOTES ON OBSERVATIONS OF NEBULAE.

By C. O. Lampland.

A continuation of the program of photographic observations of nebulae, with the 40-inch Lowell reflector, for the detection of possible changes, has met with some encouragement during the present year, in that results have been obtained in the case of the Crab Nebula (N. G. C. 1952, M 1), the spiral nebula N. G. C. 4254 (M 99), and possibly also for the Trifid Nebula (N. G. C. 6514, M 20). The first part of the paper was largely occupied with descriptions and a discussion of photographic observations of the variable nebula in Monoceros, N. G. C. 2261 (Hubble), followed by a few remarks on the previously mentioned nebulae in which changes have been discovered recently. The paper was illustrated by many slides from the 40-inch reflector photographs.

The variable nebula N. G. C. 2261 has been observed as continuously as possible since the first part of 1916. In the interval 1916-1921 over 300 photographs have been made. The nebula has undergone during the past five years remarkable changes in the brightness and structure of its detail. In the descriptions of the changes such terms as obscuration, obscuring clouds, dimming, etc., were used for convenience of expression but without thereby implying that we have any definite knowledge of the agent or of the causes of the phenomena observed. The apparent fading out or dimming down of the entire nebula or parts of it, and not infrequently the complete obliteration of some regions, with the subsequent recovery of the brightness of detail that can be identified as to position and form on photographs of preceding and following dates, is one reason for stating the activity in terms of veiling or obscuring effects.

In the comparator examinations of the earlier photographs of the series the impressions were that some of the detail might have undergone displacements, and also that some parts of the nebula appeared to remain constant in position, form and brightness. Later observations have cast doubt on the view that actual displacements of nebular matter occur and have also shown definitely that all parts of the nebula are subject to change. The behavior of the nebula has at various times suggested that one might expect recurrences of the same or similar forms. Identical forms of the nebula as a whole have not yet been observed for different epochs but images remarkably alike in their general outline, and even to minor details, have occurred.

So many parts of the nebula have been profoundly changed and have in time returned to identical earlier forms, that one might be led to believe that in the course of intervals of several years there may be repetitions of images having a very close resemblance.

Extensive areas, bands and small spots of dimming or obscuration have at various times passed over the nebula. Displacements of these obscurations have been measured with values varying from about 0″.1 to 0″.2 per day, the smaller rates being the more usual ones. The apparent motion is generally *away* from the nucleus. The great obscuration that invaded the nebula in 1919 was described at some length. In such cases the detail in the parts affected may be dimmed in varying degrees or completely obliterated. The subsequent recovery of the light of the obscured detail and the identity of position and form of the reappearing structure with that on other photographs of widely separated dates seems to be strong evidence that we are witnessing some form of veiling or obscuration. Local variations or fluctuations in the light of the nebular matter appears to be a less plausible explanation. But attention was called to the difficulty of reconciling the enormous observed velocities of the obscurations, if their measured displacements of 0″.1 or more per day are assumed to be actual motions of gross matter passing between the observer and the nebula, if we suppose the parallax of the nebula to be of the order of 0″.005 or less. The presence of absorption lanes in the sky in the vicinity of this object may indicate the presence of dark matter in and about the nebula and one might think of this dark nebular matter as subject to other influences from the nucleus besides that of direct illumination; that the nucleus may be the source of variable fields of influence in the form of radiant energy and matter (radiations and emissions). For example, streams or clouds of charged particles of high velocity might become visible upon encountering in their flight the outlying matter. No marked variations have been observed in the light of the nucleus, so that there is no obvious correlation between its apparent activity and the striking changes in the nebular structure.

A COMPUTATION OF THE SOLAR MOTION FROM THE RADIAL VELOCITIES, PROPER MOTIONS AND SPECTROSCOPICALLY DETERMINED PARALLAXES OF 762 STARS.

By E. S. Manson, Jr.

In determinations of the solar motion the point considered at rest, and to which the solar motion is referred, is the centroid of the system of stars used in the solution; i. e. the center of mass on the assumption that all of the masses are equal. Consider rectangular axes, the x-axis being in the plane of the equator and directed toward the vernal

equinox; the y-axis in the plane of the equator and directed 90° east of the vernal equinox; and the z-axis making an angle of 90° with the plane of the equator and directed toward the north. Let V_x, V_y and V_z be the components of the velocity of any star, with respect to the sun, along the axes above described. Let X, Y and Z represent the components of the velocity of the sun in the above mentioned directions and with respect to the centroid of the system of stars. Then

$$X = -\frac{1}{n}\Sigma V_x$$

$$Y = -\frac{1}{n}\Sigma V_y$$

$$Z = -\frac{1}{n}\Sigma V_z$$

where n represents the number of stars used.

In cases where the radial velocities, proper motions and parallaxes of stars are known X, Y and Z may be computed as follows: Let μ_α represent the proper motion of a star in right ascension expressed in seconds of time. Let μ_δ represent the proper motion in declination expressed in seconds of arc. Let π represent the parallax expressed in seconds of arc. Let V_α represent the linear velocity of the star at right angles to the line of sight and in the plane of the great circle perpendicular to the star's hour-circle; V_α being positive when the star's right ascension is increasing. Let V_δ represent the linear motion at right angles to the line of sight and in the plane of the star's hour-circle; V_δ being positive when the star's declination is increasing. Let V_r represent the star's radial velocity, being positive when the distance from the sun is increasing. All of the V's are to be expressed in kilometers per second. It may be shown that

$$V_\alpha = 71.05\,\frac{\mu_\alpha \cos\delta}{\pi}$$

$$V_\delta = 4.738\,\frac{\mu_\delta}{\pi}$$

After V_α and V_δ have been computed V_x, V_y and V_z may be found from the relations

$$V_x = -V_\alpha \sin\alpha - V_\delta \cos\alpha \sin\delta + V_r \cos\alpha \cos\delta$$

$$V_y = +V_\alpha \cos\alpha - V_\delta \sin\alpha \sin\delta + V_r \sin\alpha \cos\delta$$

$$V_z = +V_\delta \cos\delta + V_r \sin\delta$$

Hence the components of the solar velocity are given by

$$X = \frac{1}{n} \Sigma\,(+V_\alpha \sin\alpha + V_\delta \cos\alpha \sin\delta - V_r \cos\alpha \cos\delta)$$

$$Y = \frac{1}{n} \Sigma\,(-V_\alpha \cos\alpha + V_\delta \sin\alpha \sin\delta - V_r \sin\alpha \cos\delta)$$

$$Z = \frac{1}{n} \Sigma\,(\qquad\quad - V_\delta \cos\delta \qquad - V_r \sin\delta)$$

In the manner above described X, Y and Z were computed for each of 762 stars for which radial velocities, proper motions and parallaxes were available. Seven stars which would otherwise have been included in the solution were omitted on account of their extraordinarily high velocities. The parallaxes were obtained from the list given in *Contributions from the Mount Wilson Observatory* No. 199. The proper motions were obtained from the *Preliminary General Catalogue* of Boss when they were contained therein; in other cases from the Cincinnati catalogue of proper motions. The radial velocities were obtained from *Lick Observatory Bulletin* No. 229, and from results obtained at Mount Wilson Observatory published in *Astrophysical Journal*, **39**, 341, and **42**, 172. In a few cases means of Lick and Mount Wilson results were used. The following values of X, Y and Z were obtained:

$$X = +\ 1.710 \text{ km/sec.}$$
$$Y = -18.387 \text{ km/sec.}$$
$$Z = +12.158 \text{ km/sec.}$$

If the right ascension and declination of the apex of the sun's motion with respect to these stars are represented by A and D respectively and the velocity of the sun's motion by V,

$$\tan A = \frac{Y}{X}$$

$$V^2 = X^2 + Y^2 + Z^2$$

$$\tan D = \frac{Z}{\sqrt{(X^2 + Y^2)}}$$

From the values of X, Y and Z given above we obtain

$$A = 275°.3$$
$$D = +33°.4$$
$$V = 22.1 \text{ km/sec.}$$

Although the numerical work of this computation has been largely checked, the checking has not as yet been as thorough as is desirable. It is however improbable that there are outstanding errors sufficient to affect the last places of the values of A, D and V given above.

It was pointed out by Bravais in 1842 that if the necessary data were available the solar motion could be computed in essentially the

manner above described. He saw however no hope of obtaining radial velocities.

It should be observed that, granting the accuracy of the data employed, the above method gives the solar motion with respect to the stars used without any assumption whatever. In other methods assumptions are made, however justifiable such assumptions may be.

THE ORBIT OF ζ CENTAURI. PRELIMINARY NOTE ON v CENTAURI.

By Antonia C. Maury.

The relative orbit of this spectroscopic binary has been determined from a hundred and sixteen photographs taken at the Harvard Observatory station at Arequipa, Peru. The elements are:

$$
\begin{aligned}
P &= 8.024 \text{ days} \\
T &= \text{J. D. } 2412266.81 \\
\omega &= 287^\circ \pm 3^\circ \\
e &= .5 \\
K + K_1 &= 312 \text{ km} \pm 5 \text{ km} \\
(a + a_1) \sin i &= 29{,}800{,}000 \text{ km} \\
(m + m_1) \sin^3 i &= 16.4 \odot
\end{aligned}
$$

T is the time of crossing the line of sight with the bright star in front, and is preliminary. The spectrum of the primary is B2 and of the secondary B2 or B3, and the latter is about seven-tenths as bright as the former.

As points of interest may be noted the high velocity and the eccentricity, high for the type and period. The most important feature is the mass, which places this in the rank of μ_1 Scorpii, Y Cygni and V Puppis, as most massive known systems. Its mass is almost exactly equal to that of μ_1 Scorpii and half that of Y Cygni and V Puppis, which are respectively $32 \odot$ and $33 \odot$. All four are early B type stars.

The lines of ζ Centauri are less wide than those of μ_1 Scorpii and V Puppis, which accords with the theory that widening is due to axial rotation synchronizing with revolution.

The most striking feature of the system of v Sagittarii is the vanishing companion. The primary shows a beautiful spectrum of Class F2, but having narrow lines and strong enhanced lines of α Cygni and ϵ Aurigae, characterizing stars of supernormal light energy. At times there is superposed on this the spectrum of the B8 companion which then is dominant, effacing all the fainter lines of the primary. The hydrogen lines are then seen double, those of the companion lying toward the violet. The little star is then flying toward the earth with a relative velocity of more than 280 km a second. As the velocity of approach declines the companion fades away, becoming invisible and leaving the F2 spectrum sharp and

unobscured. No reverse doubling has been found. On 130 plates, mostly of excellent quality and well distributed over the period, the companion was seen on but ten. The period of visibility may be about three weeks, but is not yet determined. The times of doubling found from the Harvard plates do not quite agree with Dr. Ralph Wilson's period of 137.939 days and may indicate irregularity in the star's motion.

The most remarkable peculiarity of this star is the abnormal helium lines appearing in the spectrum of the F2 enhanced line component. These are present in addition to the helium lines of the B8 companion during the double phase and remain clear and sharp after the total disappearance of the helium star. This unexampled occurrence of helium lines in a Class F star raises the question whether these may not be stationary lines of helium in a surrounding medium, similar to the sharp, stationary, lines of calcium seen in some other spectroscopic binaries.

PROGRESS IN RADIAL VELOCITY OBSERVATIONS OF LONG-PERIOD VARIABLES.

By Paul W. Merrill.

The total number of long-period variables with observed radial velocities is now over 100. A short time ago a preliminary solution was made for the sun's motion with respect to 83 of these stars having Md spectra, whose velocities were determined from the bright lines. The coördinates of the apex were found to be: R.A. $= 274°$; Dec. $= +44°$; sun's velocity 56 km. The average residual radial velocity is 31 km. The "K" term was included and came out —12 km, indicating that the greater part of the well known relative displacement of the bright and dark lines is due to some shift of the bright lines other than that caused by the translatory motion of the stars. The remainder may be due to an opposite displacement of the dark lines.

PARALLAXES OF SEVENTY-THREE STARS.

By John A. Miller.

This paper gave the parallaxes of seventy-three stars as determined by the observers of the Sproul Observatory. They contained the parallaxes of some double stars whose orbits are known, of some stars of large proper motion and of some special objects. For nine of these seventy-three stars the parallaxes have been determined recently by the trigonometric method by three or more observatories, and a great number of them have been determined by two observatories.

Among the special objects contained in the list was Barnard's Proper Motion Star. The parallax of this star has been determined by six different obresvations; the separate values are: 0″.519, 0″.539, 0″.555, 0″.552, 0″.546, and 0″.559; the average, giving all the observatories equal weight, is 0″.545. A second special object is ε Hydrae. This is a double star whose visual and spectroscopic orbit is known. Therefore, its absolute parallax can be computed. The parallax found for it by the Sproul Observatory was 0″.012 and by McCormick, 0″.004, both of which are smaller than that found by Aitken by computation. A third special object is Campbell's Hydrogen Star. The parallax found by the Sproul Observatory for this object is —0″.002 and by van Maanen, 0″.005. There were also given the parallaxes of two nebulae, N. G. C. 2392, and N. G. C. 6826, which are respectively, 0″.006 and —0″.006. The list contains also two Cepheids, namely, X Cygni and RT Aurigae. The parallaxes found for these stars are respectively, 0″.000 and 0″.025. The numbers given above are all relative parallaxes.

THE NEW ELECTRIC DRIVING CLOCK OF THE PHOTOGRAPHIC TELESCOPE OF THE U. S. NAVAL OBSERVATORY.

By George Henry Peters.

The driving clock of the 26-inch equatorial telescope, as originally installed at the old Naval Observatory, was used in the conversion of the mechanical parts of this mounting into a photographic telescope, at the observatory's present location.

Recently it was decided to replace this old driving clock with one of new design. An electric clock was decided upon, and this new mechanism was constructed at the nautical instrument repair shop of the Naval Observatory, and installed as part of the photographic telescope.

The principle upon which the new electric driving clock is constructed, and its mode of operation, are briefly as follows.

A 1/6 h. p., a. c. motor of about 1750 r. p. m. is employed to furnish the power required. This motor, through a shaft carrying a 20-pound fly-wheel, is made to turn a worm-screw of six threads per inch, which drives a worm-wheel of 124 teeth. The worm-wheel is mounted upon a vertical shaft in a properly designed frame having three upright supporting posts secured to the heavy iron base plate of the clock. Above the worm-wheel and also horizontal is a circular bronze table 10 inches in diameter, which is attached to and revolves with the vertical shaft. Upon this table is securely clamped a metallic plate of special form, which acts as a cam as the table revolves, lifting a wheel attached to an arm. This mechanism, through suitable connections, operates a make and break circuit attachment controlling the current supply to the motor, when the driving clock is in operation. The lifting-wheel is

adjustable on the arm for position by means of a suitable carriage. The lifter-plate, or cam, is about 1/4 inch in thickness and of such outline that a variable part of the arc on the radius is interrupted by the wheel, with changes of position upon the radial arm, to which it is attached. This combination is the regulating device controlling the speed of the motor through the make and break, thus synchronizing its operation. Moreover, equal changes of position of this wheel on the arm give practically equal corrections to the clock rate.

A shunt is employed across the make and break, using a red bulb carbon lamp as resistance. A rheostat is also used on the motor circuit, whereby adjustments can be made for current variations.

Below the worm-wheel on the vertical shaft, the first spur gear, of 160 teeth, of the clock train is located. An idler of 72 teeth is introduced for convenience, which in turn drives a gear of 80 teeth attached through a clutch to a vertical rod. This rod, with a bevel gear at its top, operates the original driving mechanism on the "harp-shaped piece" of the old equatorial mounting.

This new driving clock is eminently satisfactory, and requires no pendulum control, although this feature could easily be installed if necessary.

PRELIMINARY PARALLAX OF THE PLEIADES.

By John H. Pitman.

A series of photographs of that portion of the Pleiades group having β 536 central was taken at the Sproul Observatory for the purpose of determining the parallax of that binary. Three additional members of the Pleiades group having about the same diameter as the comparison stars and being fairly well situated with respect to these stars were also measured. The average parallax obtained from these four stars was $+0''.017 \pm 0''.002$.

The work will be continued by a series of photographs with Alcyone central and another series covering the region about one degree south of Alcyone.

THE SPECTROSCOPIC ORBIT AND DIMENSIONS OF TV CASSIOPEIAE.

By J. S. Plaskett.

The eclipsing variable TV Cassiopeiae, R. A. $0^h\ 13.9^m$ Dec. $+58°\ 35'$ (1900), magnitude 7.3, spectral type A2, has been under spectroscopic investigation at Victoria since August 1919, and 16 plates have been obtained and measured. Although according to the photometric measures, the spectrum of the fainter component is not likely to be visible, the faint lines of a second spectrum, approximately the same type as

the primary have been seen and measured on several of the Victoria plates. The lines are very faint and difficult, and while there is a possibility they may be due to lines in the primary, the probabilities are much against this conclusion, as their position and displacement corresponds to that which would be taken by lines in the spectrum of the fainter star.

While the plates have not yet been rediscussed nor the final elements computed, the provisional spectroscopic orbit is

Period (photometric)	$P = 1.812635$ days
Eccentricity	$e = 0$
Phase (photometric and spectroscopic)	$t = 0$
Semi-amplitude brighter	$K_b = 87$ km
Semi-amplitude fainter	$K_f = 145$ km
Velocity system	$\gamma = 2$ km

Using this and McDiarmid's photometric orbit the dimensions of the system become

Radius brighter star	$r_b = 2.4$
Radius fainter star	$r_f = 2.7$
Distance between centers	$a = 8.2$
Mass brighter star	$m_b = 2.0$
Mass fainter star	$m_f = 1.2$

(To be continued.)

"With Fervent Heat."

By strange catastrophe, from cause unknown,
Our World forsakes its orbit, and is thrown,
Like vessel on the rocks, against the Sun.
A flash, a flame, a planet's course is run!

Like fleeting breath we fade with land and sea,
A tick of time concludes man's history;
What we have wrought, whatever we have reared,
Lives after us. Dross, tares have disappeared.
A flash, a flame! Man's mission is complete;
Earth's elements dissolve with fervent heat.

41 Arlington, St., Boston, Mass. CHARLES NEVERS HOLMES.

PLANET NOTES FOR JANUARY.

(The time used is Central Standard Time)

The moon's phases will be as follows:

		d	h	m	
First quarter	January	6	4	23.8	A. M.
Full moon	January	13	8	36.5	A. M.
Last quarter	January	19	11	59.8	P. M.
New Moon	January	27	5	48.2	P. M.

THE CONSTELLATIONS AT 9:00 P. M. JANUARY 1.

Mercury will be in conjunction with the moon on the 29th about 1 p. m., the planet being 3° 25′ south of the moon. Five hours later the planet will be at greatest eastern elongation.

Venus will be near the sun throughout the month, rising about 40 minutes before the sun on the 1st and 7 minutes before on the 31st.

The earth will be in perihelion on the 3rd at 9 a. m. Its distance from the sun at this time will be 91,275,000 miles.

Mars will be in conjunction with the moon at 3 p. m. on the 20th. The planet will be 1° 34′ south of the moon's center. The distance between Mars and the earth will diminish rapidly during the month, its distance on the first being 167,800,000 miles and on the last 136,500,000 miles. Its average rate of approach will therefore be over one million miles a day. The apparent diameter will increase from 5″.3 to 6″.4 in the interval.

Jupiter will be at quadrature 5 p. m. on the 8th and will therefore be on the meridian about 6 a. m. The planet will therefore be in very good position for observation during the late hours of the night.

Saturn will be in Virgo and only a few degrees northeast of Jupiter. It is therefore equally well placed for observation.

Uranus will be in conjunction with the moon at 1 P. M. on the 29th, the moon being 3° 25′ north.

Neptune will be in conjunction with the moon at 10:33 P. M. on the 14th, the planet being 4° 28′ north. Its position on this date will be $\alpha = 9^h\ 10^m\ 52^s$, $\delta = 16°\ 24'$.

Occultations Visible at Washington.

[*From the American Ephemeris.*]

Date 1922	Star's Name	Magnitude	IMMERSION. Washington M.T.	IMMERSION. Angle from N	EMERSION. Washington M.T.	EMERSION. Angle from N	Duration
			h m	°	h m	°	h m
Jan. 2	170 B Aquarii	6.0	6 35	92	7 40	218	1 05
6	263 B. Piscium	6.4	7 01	70	8 28	242	1 27
11	124 H^1 Orionis	5.7	12 54	129	13 56	246	1 02
11	292 B. Orionis	6.5	16 07	103	17 02	274	0 55
12	λ Geminorim	3.6	13 45	144	14 40	243	0 55
13	30 B. Cancri	6.1	8 35	133	9 30	244	0 55
14	209 B. Cancri	6.5	7 39	96	8 35	285	0 57
14	*h* Leonis	5.2	19 14	98	20 06	299	0 52
16	75 Leonis	5.4	13 23	91	14 32	321	1 09
16	76 Leonis	6.0	14 32	122	15 50	292	1 18

COMET NOTES.

Elements of Comet *c* 1921 (Dubiago).— In *Astronomische Nachrichten* 5123, Mr. Ebell gives the following elements of Dubiago's comet, based upon observations on the dates 1921, April 29, May 14, and May 30. The residuals for the middle place are rather large: (O-C) $\Delta\lambda \cos\beta = +36''.9$; $\Delta\beta = +6''.5$.

ELEMENTS

$T = 1921$ May 5.24446 G. M. T.
$\omega = 97°\ 40'\ 53''.7$
$\Omega = 65\ 17\ 48\ .4$ } 1921.0
$i = 22\ 31\ 16\ .3$
$\log q = 0.052702$

VARIABLE STARS.

Minima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

Star	R.A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of minima in 1922 January							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
SY Androm.	0	08.0	+43	09	9.5—13.0	34	21.8			12	15				
RT Sculptor.		31.5	—26	13	9.6—10.5	0	12.3	4	19	12	11	20	4	27	20
UU Androm		38.5	+30	24	10.7—11.9	1	11.7	5	8	12	19	20	5	27	15
U Cephei	0	53.4	+81	20	7.0— 9.0	2	11.8	7	0	14	11	21	23	29	10
Z Persei	2	33.7	+41	46	9.4—12	3	01.4	2	21	9	0	21	6	27	8
TW Cassiop.		37.6	+65	19	8.2— 9.0	1	10.3	6	13	13	17	20	20	27	23
RY Persei		39.0	+47	43	8.0—10.3	6	20.7	7	10	14	7	21	3	28	0
RZ Cassiop.		39.9	+69	13	6.9— 8.1	1	04.7	4	4	11	8	18	12	25	16
TX Cassiop.		44.4	+62	22	9.4—10.1	2	22.2	1	1	9	20	18	15	27	10
ST Persei		53.7	+38	47	8.5—10.5	2	15.6	1	1	9	0	16	23	24	21
RX Cassiop.	2	58.8	+67	11	8.6— 9.1	32	07.6			14	9				
Algol	3	01.7	+40	34	2.3— 3.5	2	20.8	9	5			17	20	26	10
RT Persei		16.7	+46	12	9.5—11.5	0	20.4	6	0	12	19	19	14	26	9
λ Tauri		55.1	+12	12	3.3— 4.2	3	22.9	1	9	9	7	17	4	25	2
RW Tauri	3	57.8	+27	51	7.1—<11	2	18.5	2	10	10	17	19	1	27	8
RV Persei	4	04.2	+33	59	9.5—11.0	1	23.4	3	2	11	0	18	21	26	19
RW Persei		13.3	+42	04	8.8—11.0	13	04.8			12	1			25	6
SZ Tauri		31.4	+18	20	7.2— 7.7	3	03.6	7	15			17	1	26	12
RS Cephei	4	48.6	+80	06	9.5—12.0	12	10.1			9	20			22	6
TT Aurigæ	5	02.8	+39	27	7.8— 8.7	0	16.0	2	10	9	2	22	10	29	2
RY Aurigæ		11.5	+38	13	10.7—11.7	2	17.5			9	23	18	4	26	8
RZ Aurigæ		42.9	+31	40	10.6—13.3	3	00.3	1	2	13	3	19	3	25	4
SV Tauri		45.8	+28	05	9.4—11.0	2	04.0	5	11	14	3	22	19	31	11
Z Orionis		50.2	+13	40	9.7—10.7	5	04.9	7	16			18	2	28	12
SV Gemin.		54.6	+24	28	9.8—<11	4	00.2	7	4	15	4	23	4	31	5
RW Gemin.	5	55.4	+23	08	9.5—11.0	2	20.8	1	13	7	6	18	17	30	5
U Columbæ	6	11.2	—33	03	9.2—10.0	2	19.2	4	19	10	10	16	0	27	5
SX Gemin.		22.0	+20	37	10.8—11.5	1	08.8			8	16	16	21	25	2
RW Monoc		29.3	+ 8	54	9.0—10.8	1	21.7	8	9	16	0	23	15	31	6
RX Gemin.		43.6	+33	21	8.8— 9.6	12	05.0	5	21			18	2	30	7
RU Monoc.	6	49.4	— 7	28	9.8—10.5	0	21.5	1	21	9	1	16	5	23	9
R Can. Maj.	7	14.9	—16	12	5.8— 6.4	1	03.3	2	13	9	8	16	4	23	0
RY Gemin.		21.7	+15	52	8.9—<10	9	07.2	1	5	10	12	19	19	29	2
Y Camelop.		27.6	+76	17	9.5—12	3	07.3	1	7	7	22	14	12	21	3
TX Gemin.		30.3	+17	08	10.0—11.9	2	19.2	2	5	10	15	19	0	27	10
RR Puppis		43.5	—41	08	9.4—10.7	6	10.3	4	13	10	23	17	9	30	6
V Puppis	7	55.4	—48	58	4.1— 4.8	1	10.9	2	4	9	11	24	0	31	7
X Carinae	8	29.1	—58	53	7.9— 8.7	0	13.0	4	16	12	19	20	22	29	1
S Cancri	8	38.2	+19	24	8.2—10	9	11.6	6	18			16	6	25	18
RX Hydræ	9	00 8	— 7	52	9.1—10.5	2	06.8	2	5	9	2	22	18	29	15
S Velorum		29.4	—44	46	7.8— 9.3	5	22.4	6	4	12	2	18	0	29	21
Y Leonis	9	31.1	+26	41	9.3—11.2	1	16.5	3	13	10	12	17	6	24	0
RR Velorum	10	17.8	—41	36	10.0—10.9	1	20.5			10	15	18	1	25	11
SS Carinæ	10	54.2	—61	23	12.2—12.8	3	07.2	4	8	11	23	24	4	30	18
ST Urs. Maj.	11	22.4	+45	44	6.7— 7.2	8	19.2	5	5	14	0	22	20	31	15
RW Urs. Maj.		35.4	+52	34	10.3—11.4	7	07.9	6	21	14	5	21	13	28	21
Z Draconis	11	39.8	+72	49	9.9—13.6	1	08.6	3	4	9	9	23	12	30	7
RZ Centauri	12	55.6	—64	05	8.5— 8.9	1	21.0	5	7	12	20	20	8	27	20
RS Can. Ven.	13	06.3	+36	28	7.5—12.5	4	19.1	5	15	15	5	24	20		
SS Centauri		07.2	—63	37	8.8—10.4	2	11.5	8	4	15	14	23	6	30	11
133926 Hydræ	13	39.0	—26	23	8.6—12.7	2	21.5	5	20	17	10	23	5	28	23

Minima of Variable Stars of Short Period—Continued.

Star	R.A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of minima in 1922 January							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
δ Libræ	14	55.6	—	8 07	4.8— 6.2	2	07.9	6	17	13	8	20	18	27	15
U Coronæ	15	14.1	+32	01	7.6— 8.7	3	10.9	3	15	10	13	24	8	31	6
TW Draconis		32.4	+64	14	7.3— 8.9	2	19.3	2	8	10	18	19	4	27	14
SS Librae	15	43.4	—15	14	9.3—11.5	0	18.4	6	9	14	1	21	17	29	8
SW Ophiuchi	16	11.1	—	6 44	9.2—10.0	2	10.7	2	21	10	5	17	14	24	22
SX Ophiuchi		12.6	—	6 25	10.5—11.2	2	01.5	3	6	11	12	19	18	28	1
R Aræ		31.1	—56	48	6.8— 7.9	4	10.2	6	7	15	3	23	23		
TT Herculis	16	49.9	+17	00	8.9— 9.3	20	18.1					17	2		
TU Herculis	17	09.8	+30	50	9.5—12	2	06.4	4	15	11	10	18	6	25	1
U Ophiuchi		11.5	+	1 19	6.0— 6.7	0	20.1	5	10	13	20	22	5	30	14
u Herculis		13.6	+33	12	4.6— 5.4	2	01.2	1	14	13	22	20	1	26	5
TX Herculis		15.4	+42	00	8.3— 9.0	1	00.7	7	6	13	11	19	15	25	19
RV Ophiuchi		29.8	+	7 19	9. —12	3	16.5	5	21	13	6	20	15	28	0
SZ Herculis		36.0	+33	01	9.5—10.3	0	19.6	5	4	13	8	21	12	29	17
TX Scorpii		48.6	—34	13	7.5— 8.2	0	22.6	8	7	15	20	23	9	30	22
UX Herculis		49.7	+16	57	8.8—10.5	1	13.2	5	20	13	14	21	8	29	2
Z Herculis		53.6	+15	09	7.1— 7.9	3	23.8	1	7	9	6	17	6	25	6
WX Sagittarii		53.6	—17	24	9.2—10.8	2	03.1	1	18	10	6	18	19	27	7
WY Sagittarii	17	54.9	—23	01	9.5—10.6	4	16.0	2	10	11	18	21	2	30	10
SX Draconis	18	03.0	+58	23	9.3—10.5	5	04.1	1	12	11	20	22	4		
RS Sagittarii		11.0	—34	08	5.9— 6.3	2	10.0	9	23	17	5	24	11	31	17
V Serpentis		11.1	—15	34	9.5—11.1	3	10.9	8	17	15	15	22	13	29	11
RZ Scuti		21.1	—	9 15	7.4— 8.3	15	03.2	4	6			19	8		
RZ Draconis		21.8	+58	50	9.5—10.2	0	13.2	5	23	14	3	21	7	28	11
RX Herculis		26.0	+12	32	7.0— 7.6	0	21.3	6	1	13	3	20	6	27	9
SX Sagittarii		39.7	—30	36	8.7— 9.8	2	01.8	2	15	10	22	19	6	27	13
RR Draconis		40.8	+62	34	9.3—13	2	19.9	1	21	10	9	18	20	27	8
RS Scuti		43.7	—10	21	9.3—10.3	0	15.9	2	19	9	10	16	2	29	9
β Lyræ		46.4	+33	15	3.4— 4.1	12	21.8			9	5			22	2
U Scuti	18	48.9	—12	44	9.1— 9.6	0	22.9	1	12	9	3	16	19	24	10
RX Draconis	19	01.1	+58	35	9.3—10.2	1	21.4	1	23	9	13	17	3	24	17
RV Lyræ		12.5	+32	15	11. —12.8	3	14.4	2	18	9	23	17	4	29	9
RS Vulpec.		13.4	+22	16	6.9— 8.0	4	11.4	4	18	13	17	22	16	31	15
U Sagittæ		14.4	+19	26	6.5— 9.0	3	09.1	5	0	11	18	18	12	25	7
Z Vulpec.		17.5	+25	23	7.3— 8.5	2	10.9	5	8	2	17	20	2	27	10
TT Lyræ		24.3	+41	30	9.4—11.6	5	05.8	2	14	13	2	18	8	28	20
UZ Draconis		26.1	+68	44	9.0— 9.8	1	15.1	7	6	13	19	20	7	26	20
SY Cygni	19	42.7	+32	28	10 —12	6	00.2	4	17	10	18	16	18	28	18
WW Cygni	20	00.6	+41	18	9.3—13.4	3	07.6	1	1	7	16	14	7	27	14
SW Cygni		03.8	+46	01	9. —11.7	4	13.8	4	11	13	15	22	18		
VW Cygni		11.4	+34	12	9.8—11.8	8	10.3	4	4	12	14	21	1	29	11
RW Capric.		12.2	—17	59	8.8—10.6	3	09.4	1	1	7	20	14	16	28	4
UW Cygni		19.6	+42	55	10.5—13	3	10.8	3	4	10	1	23	20	30	18
V Vulpec.		32.3	+26	15	8.2— 9.8	37	19.0	7	11						
W Delphini		33.1	+17	56	9.4—12.1	4	19.4	7	0			16	14	26	5
RR Delphini		38.9	+13	35	10.5—11.8	4	14.4			8	6	17	11	26	16
Y Cygni		48.1	+34	17	7.1— 7.9	1	12.0	4	0	11	9	18	21	26	9
WZ Cygni		49.3	+38	27	9.9—10.8	0	14.0	7	9	15	0	22	13	30	3
RR Vulpec.	20	50.5	+27	32	9.6—11.0	5	01.2			10	2	20	4	30	6
VVCygni	21	02.3	+45	23	12.1—13.8	1	11.4	5	15	13	0	20	9	27	19
AE Cygni		09.0	+30	20	10.8—11.4	0	23.3	5	14	15	6	24	23		
RY Aquarii		14.8	—11	14	8.8—10.4	1	23.2	5	21	13	18	21	15	29	12
RT Lacertæ	21	57.4	+43	24	9.1—10.5	5	01.7	1	11	11	14	21	18	31	21
UZ Cygni		55.2	+43	52	8.9—11.6	31	07.3			13	21				
RW Lacertæ	22	40.6	+49	08	10.2—11.2	5	04.4	4	9	9	13	19	22	25	2
8.1914 Pegasi		51.7	+32	41	10.0—10.6	5	06.4	2	3	7	10	23	5	28	11
TT Androm.	23	08.7	+45	36	11.3—12.6	2	18.4			8	17	16	23	24	7
Y Piscium		29.3	+	7 22	9.0—12.0	3	18.3	3	23	11	11	19	0	26	13
TW Androm.	23	58.2	+32	17	8.6—11.5	4	02.9	6	5	14	11	22	17	30	23

Maxima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1922 January							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.2	36 13.7			13 7					
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 01.7			9 1		17 4		25 7	
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	4 8		12 2		19 20		27 13	
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2	1 12				16 7		31 3	
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	5 19		13 18		21 16		29 15	
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	5 6		13 1		20 20		28 15	
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	3 16		10 23		18 6		25 12	
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	2 —				18 —			
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	7 5		15 19		24 9			
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	6 12				17 15		28 18	
RX Aurigæ	4 54.5	+39 49	7.2— 8.1	11 15.0	4 1		15 16				27 7	
SX Aurigæ	5 04.6	+42 02	8.0— 8.7	1 12.8	5 23		13 14		21 6		28 22	
SY Aurigæ	05.5	+42 41	8.4— 9.5	10 03.3			9 2		19 5		29 8	
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	7 7		15 0		22 18		30 11	
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	2 13		13 15		19 3		30 5	
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	1 16		9 6		24 9		31 23	
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3	3 17						30 17	
RT Aurigæ	23.0	+30 33	5.1— 6.0	3 17.5	1 8		16 6		23 17		31 4	
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	1 4		8 9		22 19		30 0	
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	3 10		11 8		19 6		27 4	
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	3 17		13 21		24 1			
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5					21 4			
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	5 17		13 15		21 14		29 13	
V Carinæ	8 26.7	—59 47	7.4— 8.1	6 16.7	5 22		12 14		19 7		26 0	
T Velorum	8 34.4	—47 01	7.6— 8.5	4 15.3	2 21		12 4		21 10		30 17	
V Velorum	9 19.2	—55 32	7.5— 8.2	4 08.9			9 2		17 20		26 14	
Z Leonis	9 46.4	+27 22	7.9— 9.6	59 00.0					21 —			
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	7 11		14 6		21 1		27 20	
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	3 16		10 6		23 11		30 2	
S Muscæ	12 07.4	—69 36	6.4— 7.3	9 15.8			8 19		18 11		28 3	
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7			8 3		16 3		24 2	
T Crucis	15.9	—61 44	6.8— 7.6	6 17.6	4 20		11 14		18 7		25 1	
R Crucis	18.1	—61 04	6.8— 7.9	5 19.8	4 21		10 16		22 8		28 4	
S Crucis	12 48.4	—57 53	6.5— 7.6	4 16.6	1 0		10 9		15 2		29 4	
W Virginis	13 20.9	— 2 52	8.7—10.4	17 06.5			15 22					
SS Hydræ	25.0	—23 08	7.4— 8.1	8 04.8	6 10		14 14		22 19		31 0	
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	8 22		15 22		22 23		29 23	
ST Virginis	14 22.5	— 0 27	10.3—11.4	0 09.9	6 20		15 1		23 6		31 12	
V Centauri	25.4	—56 27	6.4— 7.8	5 11.9	8 4		13 15		19 3		30 3	
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	2 5		9 18		17 7		24 20	
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	7 12		14 22		22 7		29 17	
R Triang. Austr.	15 10.8	—66 08	6.7— 7.4	3 09.3	6 2		12 20		19 15		26 10	
S Triang. Austr.	15 52.2	—63 29	6.4— 7.4	6 07.8	5 2		11 9		24 1		30 9	
S Normæ	16 10.6	—57 39	6.6— 7.6	9 18.1			10 12		20 6		30 0	
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	4 4		13 13		21 21		30 18	
RV Scorpii	16 51.8	—33 27	6.7— 7.4	6 01.5	3 11		9 12		15 14		27 17	
X Sagittarii	17 41.3	—27 48	4 4— 5.0	7 00.3	7 12		14 12		21 12		28 13	
V Ophiuchi	47.3	— 6 07	6.1— 6.5	17 02.9	3 12				20 15			
W Sagittarii	17 58.6	—29 35	4.3— 5.1	7 14.3	3 16		11 7		18 21		26 11	
Y Sagittarii	18 15.5	—18 54	5.4— 6.2	5 18.6	6 8		12 2		23 16		29 10	
U Sagittarii	26.0	—19 12	6.5— 7.3	6 17.9	7 10		14 4		20 22		27 16	
Y Scuti	32.6	— 8 27	8.7— 9.2	10 08.3			8 12		18 20		29 5	
Y Lyræ	34.2	+43 52	11.3—12.3	0 12.1	4 8		10 9		16 10		28 12	
RZ Lyræ	18 39.9	+32 42	9.9—11.2	0 12.3	2 20		8 23		21 6		27 9	

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1922 January					
	h m	° ′		d h	d h	d h	d h	d h	d h	d h
RT Scuti	18 44.1	—10 30	9.1— 9.7	0 11.9	3 5	9 3	21 1	26 23		
κ Pavonis	18 46.6	—67 22	3.8— 5.2	9 02.2	2 5	11 7	20 9	29 11		
U Aquilæ	19 24.0	— 7 15	6.2— 6.9	7 00.6	4 5	11 5	18 6	25 6		
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	3 16	10 16	24 16	31 16		
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	3 2	11 2	19 1	27 1		
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	8 3	15 19	23 12	31 4		
η Aquilæ	47.4	+ 0 45	3.7— 4.5	7 04.2	3 13	10 17	17 22	25 2		
S Sagittæ	51.5	+16 22	5.6— 6.4	8 09.2		9 9	17 18	26 3		
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	7 17	14 1	20 8	26 16		
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3		14 15		31 0		
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	3 0	11 21	16 7	25 4		
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	4 12	11 6	24 17	31 11		
RV Capric.	55.9	—15 37	9.2—10.1	0 10.7	5 23	12 16	19 9	26 2		
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4		10 21		25 14		
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	4 4	12 1	19 21	27 18		
SW Aquarii	10.2	— 0 20	9.9—10.8	0 11.0	7 8	14 6	21 3	28 0		
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	4 1	13 18	18 15	28 9		
Y Lacertæ	22 05.2	+50 33	9.1— 9.6	4 07.8		10 18	19 10	28 1		
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	2 4	7 12	18 6	29 0		
Z Lacertæ	36.9	+56 18	8.2— 9.0	10 21.1		11 19		22 16		
RR Lacertæ	37.5	+55 55	8.5— 9.2	6 10.1		13 17	20 3	26 13		
V Lacertae	44.5	+55 48	8.5— 9.5	4 23.6	5 10	15 9	25 8	30 7		
X Lacertæ	22 45.0	+55 54	8.2— 8.6	5 10.7	5 18	11 5	22 2	27 13		
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	3 19	9 6	20 3	31 0		
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	1 11	14 1	20 8	26 15		
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4	6 20		19 0	31 3		
V Cephei	23 51.7	+82 38	6.0— 7.0	0 23.9	5 7	12 6	19 6	26 6		

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, September 20 to October 20, 1921.

Among lectures given recently, at which lantern slides owned by the Association were used, were those of Rev. W. C. Taylor, Martinsburg, Virginia; one by Miss Cannon before the Associated Women's Clubs of Chicago; and two by Mr. Olcott, one at Storrs Agricultural College, the other at Mansfield, Mass. Several new slides have been received from Mr. Parkhurst at Yerkes.

Mr. Howard O. Eaton is spending the first semester at Leipzig, Germany.

Mr. C. F. Whitehorn has returned to the list of active observers.

The tenth annual meeting of the Association was held at Harvard College Observatory, November 5, 1921. The keen interest of the members in their association brought together about fifty, not only from New England but from more distant states. Professor Bailey welcomed the members at the business meeting, and recommended that the Association, as a corporate body which is increasing in membership, property, and importance, broaden its scope by the introduction of photographic methods by those skilled in that line; that a committee on mechanical construction be appointed for the assistance of those contemplating making their own instruments; and that the Association look forward to printing a journal of its own.

VARIABLE STAR OBSERVATIONS, September 20 to October 20, 1921.

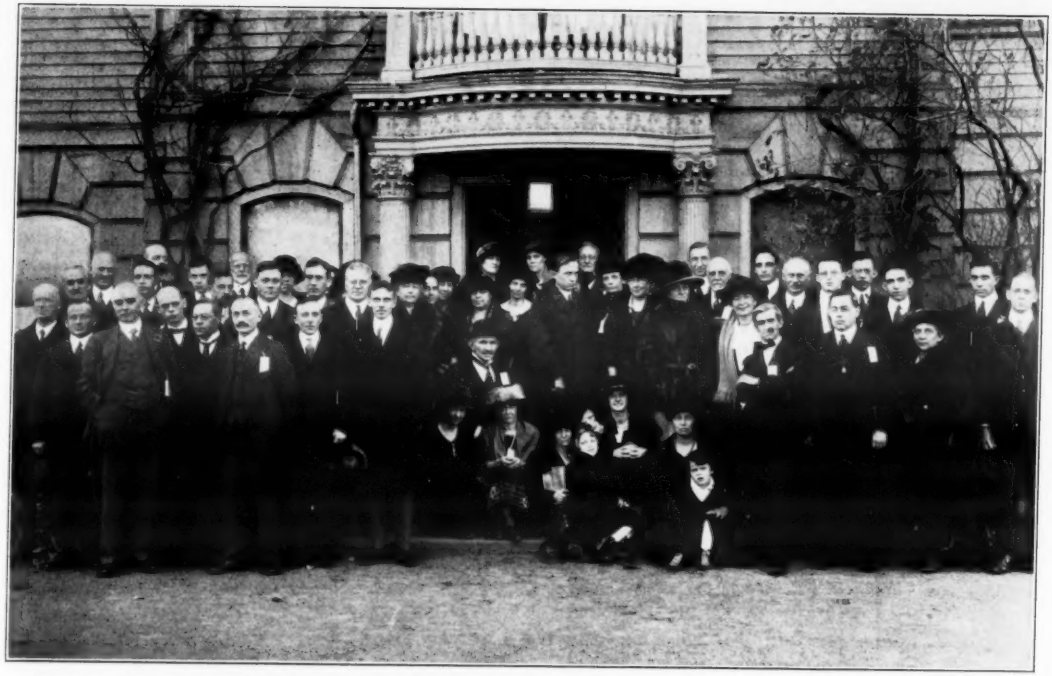
September 0 = 2422933 October 0 = 2422963

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
004435 V ANDROMEDAE—												
	2955.6	10.8	M.	2965.5	11.1	O.	2968.6	10.3	Hu.			
004633 RR ANDROMEDAE—												
	2947.8	<12.6	Wf.	2956.6	<11.6	M.	2956.8	<12.6	Wf.	2964.6	13.6	B.
	2967.9	14.5	Wf.									
004746a RV CASSIOPEIAE—												
	2956.3	<14.0	L.	2956.6	<14.2	B.						
004958 W CASSIOPEIAE—												
	2941.5	10.4	Gi.	2955.6	9.6	B.	2962.5	9.5	Rk.	2969.8	10.6	M.
	2971.6	9.1	B.									
010102 Z CETI—												
	2971.6	9.0	B.									
010940 U ANDROMEDAE—												
	2954.6	<11.5	M.	2964.7	12.3	B.						
011041 UZ ANDROMEDAE—												
	2954.6	<11.5	M.	2964.6	13.7	B.						
011272 S CASSIOPEIAE—												
	2938.4	10.0	Rk.	2955.4	10.1	Rk.	2957.9	11.1	Wf.	2960.5	10.8	Pt.
	2967.9	10.7	Wf.	2968.8	11.0	M.	2971.6	10.5	B.			
011208 S PISCIUM—												
	2959.6	11.1	Y.	2966.8	11.7	M.	2968.5	11.5	O.			
011712 U PISCIUM—												
	2966.8	11.6	M.	2967.8	11.3	Pt.						
012350 RZ PERSEI—												
	2957.6	12.1	Y.									
012502 R PISCIUM—												
	2959.6	11.7	Y.	2961.5	12.1	Rk.	2967.8	12.0	Pt.	2968.5	11.7	O.
	2968.8	11.2	M.									
013238 RU ANDROMEDAE—												
	2909.2	10.3	Ch.	2963.8	11.8	Wf.	2969.7	12.4	Wf.	2971.6	12.5	B.
013338 Y ANDROMEDAE—												
	2909.2	<11.0	Ch.	2952.5	10.9	O.	2961.6	9.5	Pt.			
014958 X CASSIOPEIAE—												
	2955.6	12.0	B.	2956.6	12.0	M.	2957.6	12.0	Y.			
015354 U PERSEI—												
	2953.7	10.5	Mu.	2962.6	10.5	Pt.	2963.5	9.5	Cg.	2971.6	10.3	B.
015912 S ARIETIS—												
	2967.8	10.9	Pt.									
021024 R ARIETIS—												
	2940.6	9.9	Gi.	2941.4	10.5	Pe.	2946.3	9.7	L.	2958.4	9.1	Gi.
	2959.6	8.3	Ga.	2960.6	9.0	L.	2962.6	8.8	M.	2962.6	8.5	Pt.
	2965.5	8.3	O.	2969.6	8.0	Ca.	2973.6	8.0	O.	2975.7	7.9	B.
021143a W ANDROMEDAE—												
	2946.5	7.8	Gi.	2947.8	8.3	Wf.	2952.5	8.2	O.	2956.6	8.8	M.
	2963.8	8.7	Wf.	2965.5	8.6	O.	2969.7	8.1	Wf.	2975.7	8.6	B.
021403 o CETI—												
	2903.4	5.4	Ch.	2923.6	6.8	Bp.	2934.4	7.0	Pe.	2934.5	7.3	Bp.
	2940.5	7.5	Bp.	2941.5	7.5	Pe.	2945.5	7.7	Bp.	2956.6	7.5	L.
	2958.4	7.7	Pe.	2958.6	7.8	Bp.	2959.6	7.6	Ca.	2961.4	8.1	Pe.
	2962.8	8.0	M.	2964.9	8.2	Bh.	2967.8	7.5	Pt.	2969.6	7.9	Ca.
	2969.8	8.2	M.	2976.7	7.9	Ca.						
022000 R CETI—												
	2969.8	<11.5	M.									
022150 RR PERSEI—												
	2957.6	<13.0	Y.									
022813 U CETI—												
	2967.8	9.9	Pt.									
023080 RR CEPHEI—												
	2947.8	13.2	Wf.	2956.3	13.1	L.	2963.8	13.6	Wf.	2969.7	13.8	Wf.
	2976.8	<11.0	M.									

VARIABLE STAR OBSERVATIONS, September 20 to October 20, 1921—Continued.

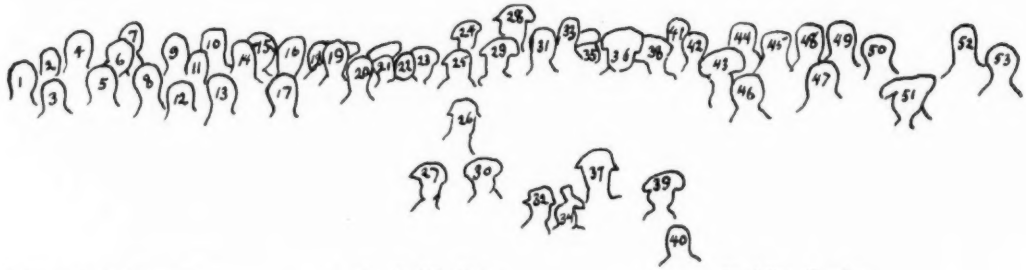
Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
023133 R TRIANGULI—												
	2953.7	9.6	Mu,	2957.4	11.7	Rk,	2962.6	12.0	M,	2962.6	11.8	Pt,
	2964.7	9.5	Mu,	2975.7	11.5	B.						
024356 W PERSEI—												
	2941.4	10.8	Pe,	2952.5	9.9	O,	2953.7	10.2	Mu,	2955.3	10.7	Pe,
	2961.6	9.3	Ca,	2962.6	10.0	M,	2962.6	10.2	Pt,	2977.6	9.4	Ca.
030514 U ARIETIS—												
	2958.5	13.1	Gi,	2959.6	13.3	Y,	2963.8	<11.4	M,	2971.7	13.3	Y.
031401 X CETI—												
	2947.9	9.5	Wf,	2956.6	9.7	L,	2963.8	10.3	M,	2963.8	10.5	Wf,
	2967.8	10.5	Pt.	2969.8	10.6	Wf.						
032043 Y PERSEI—												
	2941.4	9.8	Pe,	2952.6	8.8	O,	2953.7	9.6	Mu,	2961.4	9.0	Pe.
	2962.6	8.3	Pt,	2964.7	8.6	Mu,	2973.6	8.2	O.			
032335 R PERSEI—												
	2940.6	10.2	Gi,	2958.4	12.0	Gi,	2962.7	<11.3	M.			
035916 V ERIDANI—												
	2966.8	9.4	M.									
041619 T TAURI—												
	2961.8	10.0	M.									
042215 W TAURI—												
	2961.8	10.5	M,	2962.4	10.2	Pe,	2967.8	10.2	Pt.			
042209 R TAURI—												
	2961.8	9.0	M,	2967.8	9.5	Pt.						
042309 S TAURI—												
	2961.8	<11.7	M.									
043065 T CAMELOPARDALIS—												
	2950.3	10.5	L,	2961.4	11.2	L,	2962.8	10.8	M.			
043274 X CAMELOPARDALIS—												
	2955.3	8.3	Rk,	2957.6	8.2	Y,	2962.8	8.6	M,	2965.5	8.7	O,
	2968.8	9.2	Pt.									
043208 RX TAURI—												
	2961.8	11.0	M,	2967.8	11.7	Pt.						
043738 R CAELI—												
	2968.9	<11.2	Bh.									
044617 V TAURI—												
	2961.8	<12.3	M.									
045307 R ORIONIS—												
	2934.6	9.8	Gi,	2959.6	10.5	Gi,	2962.8	11.5	M.			
045514 R LEPORIS—												
	2956.7	8.0	L,	2963.8	9.0	M,	2964.9	8.8	Bh,	2967.8	8.0	Pt,
	2972.9	9.3	Wl,	2976.8	8.6	Ca.						
050003 V ORIONIS—												
	2969.8	13.0	M.									
050022 T LEPORIS—												
	2967.8	10.4	Pt,	2976.8	11.3	M.						
050953 R AURIGAE—												
	2961.8	8.6	M,	2967.8	9.0	Pt.						
051247 T PICTORIS—												
	2968.9	<11.8	Bh.									
051533 T COLUMBAE—												
	2964.9	9.2	Bh.									
052036 W AURIGAE—												
	2942.6	11.0	Gi,	2956.6	12.0	L,	2961.8	12.4	M,	2968.8	11.2	Pt.
052034 S AURIGAE—												
	2956.6	8.4	L,	2961.8	9.6	M.						
052404 S ORIONIS—												
	2961.8	10.0	M.									
053068 S CAMELOPARDALIS—												
	2962.7	9.3	M,	2968.8	8.8	Pt.						

PLATE XXIX



TENTH ANNUAL MEETING OF THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS.
HELD AT CAMBRIDGE, MASSACHUSETTS, NOVEMBER 5, 1921.

KEY TO PLATE XXIX.



1 W. D. MacPherson
2. A. C. Perry
3. F. H. Spinney
4. W. H. Reardon
5. M. J. Jordan
6. E. W. Clement
7. J. E. G. Yalden
8. W. Fisher
9. W. W. Bickell
10. S. I. Bailey
11. H. T. Stetson
12. D. Potter
13. Miss Corkum
14. O. L. Dustheimer
15. A. Tarwater
16. B. Lindblad
17. M. F. Jordan
18. Miss Leland
19. C. W. Elmer
20. W. T. Olcott
21. Miss Cushman
22. Miss Maury
23. Miss Swartz
24. Mrs. Alcott
25. Miss Hodgdon
26. C. Y. McAteer
27. Mrs. Elmer
28. Mrs. Norcross
29. Mrs. Campbell
30. Miss Gill
31. H. Shapley
32. Miss Allen
33. E. S. King
34. Miss Shapley
35. Miss Young
36. Miss Cannon
37. Miss Fowler
38. Mrs. Sawyer
39. Miss Harwood
40. Master Shapley
41. C. J. Hudson
42. E. F. Sawyer
43. Mrs. Morris
44. E. F. Carpenter
45. C. T. Whitehorn
46. L. Campbell
47. H. E. Melzar
48. D. H. Menzel
49. L. A. Brigham
50. L. J. Boss
51. Miss Woods
52. W. J. Delmhorst
53. C. A. Mowry

VARIABLE STAR OBSERVATIONS, September 20 to October 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
053005a T ORIONIS—												
	2956.7	11.1	L,	2960.7	11.3	L,	2961.8	11.2	M,	2968.8	11.2	Pt,
	2972.9	11.2	Wl.									
053326 RR TAURI—												
	2961.8	<11.8	M.									
053531 U AURIGAE—												
	2971.6	<12.8	Y.									
054319 SU TAURI—												
	2947.9	9.3	Wf,	2956.6	9.5	L,	2958.6	9.5	L,	2960.7	9.4	L,
	2961.8	9.4	M,	2963.8	9.6	Wf,	2964.9	9.5	Wf,	2965.8	9.5	Wf,
	2967.8	9.5	Pt,	2968.8	9.5	Pt,	2968.8	9.4	Wf,	2968.9	9.6	Bh,
	2969.8	9.3	Wf,	2971.7	9.6	Y,	2972.8	9.5	Wf,	2975.8	9.4	Pt.
054615a Z TAURI—												
	2961.8	11.5	M.									
054974 V CAMELOPARDALIS—												
	2941.5	9.8	Gi,	2957.6	11.1	Y,	2958.4	10.5	Gi,	2961.8	11.0	M,
	2965.5	11.2	O,	2968.8	11.2	Pt.						
054920 U ORIONIS—												
	2961.8	7.4	M,	2968.8	7.7	Pt,	2969.7	7.1	Ca,	2976.7	7.3	Ca,
055353 Z AURIGAE—												
	2957.6	10.6	Y,	2961.8	10.7	M,	2963.8	10.7	Wf,	2968.8	10.9	Pt,
	2969.7	10.9	Wf.									
060450 X AURIGAE—												
	2961.8	9.0	M,	2968.8	8.6	Pt.						
060547 SS AURIGAE—												
	2934.6	<13.9	Gi,	2935.6	<13.9	Gi,	2936.6	<13.9	Gi,	2938.6	<13.9	Gi,
	2940.6	<13.9	Gi,	2941.6	<13.9	Gi,	2942.6	<13.9	Gi,	2943.6	<13.8	Gi,
	2944.6	<13.8	Gi,	2946.6	<13.9	Gi,	2947.6	<13.8	Gi,	2948.6	<13.8	Gi,
	2954.6	<11.0	Pt,	2955.6	<13.8	Gi,	2956.4	<13.3	L,	2956.6	<13.8	Gi,
	2956.7	<11.0	Pt,	2957.4	<14.0	L,	2957.6	<13.8	Gi,	2958.5	<13.9	Gi,
	2958.6	<14.5	L,	2959.4	<14.5	L,	2959.6	<13.8	Gi,	2959.6	<13.3	Y,
	2960.6	<14.0	L,	2961.4	<13.3	L,	2961.8	<12.4	M,	2963.4	<13.3	L,
	2963.5	<13.9	Gi,	2964.6	14.5	L,	2965.3	12.3	L,	2965.6	10.8	L,
	2966.2	10.5	L,	2966.4	10.5	L,	2966.8	10.5	M,	2967.8	10.6	Pt,
	2968.5	10.5	O,	2968.8	10.6	M,	2968.8	10.6	Pt,	2969.8	10.6	M,
	2971.6	10.8	Y,	2971.8	10.6	M,	2975.8	11.5	M,	2975.8	11.2	Pt,
	2976.6	12.0	Y,	2976.8	11.7	M,	2977.6	<12.0	Y.			
061647 V AURIGAE—												
	2961.8	10.0	M.									
061702 V MONOCEROTIS—												
	2968.8	11.0	M,	2968.8	11.0	Pt.						
063159 U LYNCIS—												
	2957.6	11.2	Y.									
063308 R MONOCEROTIS—												
	2969.8	11.4	M.									
063658 S LYNCIS—												
	2968.8	9.8	Pt.									
064030 X GEMINORUM—												
	2942.6	8.9	Gi.									
064707 W MONOCEROTIS—												
	2975.8	10.2	Pt.									
064932 NOVA GEMINORUM #2—												
	2958.6	13.6	L.									
065111 Y MONOCEROTIS—												
	2969.8	12.2	M.									
065208 X MONOCEROTIS—												
	2956.7	7.3	L.									
065355 R LYNCIS—												
	2935.6	10.1	Gi,	2959.6	11.3	Y,	2969.8	11.7	M.			
070122a R GEMINORUM—												
	2968.8	7.2	Pt,	2969.8	7.4	M,	2976.7	7.0	Ca.			

VARIABLE STAR OBSERVATIONS, September 20 to October 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
070122b Z GEMINORUM—	2968.8	12.4	Pt.	2969.8	12.4	M.						
070122c TW GEMINORUM—	2969.8	8.8	M.	2976.7	8.1	Ca.						
070109 V CANIS MINORIS—	2976.8	8.3	M.									
070310 R CANIS MINORIS—	2956.7	11.7	L.	2976.8	10.4	M.						
071044 L_2 PUPPIS—	2964.9	3.8	Bh.									
071713 V GEMINORUM—	2968.8	10.7	Pt.	2969.8	10.0	M.						
072708 S CANIS MINORIS—	2956 7	9.1	L.	2961.8	10.2	M.	2968.8	10.5	Pt.	2968.9	10.0	Bh.
	2976.8<10.0 Ca.											
072811 T CANIS MINORIS—	2969.8<12.5 M.											
073508 U CANIS MINORIS—	2956.7	9.6	L.	2968.8	9.2	Pt.	2976.8	9.2	M.			
073723 S GEMINORUM—	2969.8<12.4 M.											
074323 T GEMINORUM—	2969.8<12.0 M.											
074922 U GEMINORUM—	2934.6<13.3 Gi.			2935.6<13.3 Gi.			2936.6<13.7 Gi.			2938.6<13.7 Gi.		
	2940.6<13.7 Gi.			2941.6<13.7 Gi.			2942.6<13.7 Gi.			2944.6<13.7 Gi.		
	2946.6<13.7 Gi.			2947.6<13.3 Gi.			2948.6<13.3 Gi.			2955.6<13 3 Gi.		
	2956.6<13.7 Gi.			2956.6<13 7 L.			2957.6<13.3 Gi.			2958.6<13.3 Gi.		
	2958.6<13.7 L.			2959.6<13.3 Gi.			2960.6<13 3 L.			2963.6	13.9	Gi.
	2965.9<13.3 Wf.			2967.8<13.3 Pt.			2968.0<13.7 Wf.			2968.8<12.4 Pt.		
	2969.8<12.4 M.			2975.8<13.3 Pt.								
081112 R CANCRI—	2958.7	11.6	L.	2975 8	11.8	Pt.						
082405 RT HYDRAE—	2960.7	7.8	L.									
083019 U CANCRI—	2968.0	11.0	Wf.									
084803 S HYDRAE—	2975.8	11.0	Pt.									
085008 T HYDRAE—	2975.8	11.3	Pt.									
085120 T CANCRI—	2958.7	9.4	L.	2975.9	8.9	Pt.						
090425 W CANCRI—	2958.7	12.6	L.	2968.0	12.6	Wf.						
093178 Y DRACONIS—	2959.6	9.5	Y.	2963.6	8.7	Y.	2965.5	8.6	Gd.	2971.7	9.0	Y.
093934 R LEONIS MINORIS—	2958.7	10.2	L.									
094211 R LEONIS—	2975.9	7.0	Pt.									
103769 R URSAE MAJORIS—	2905.1	10.8	Ch.	2934.8	7.9	Hj.	2936.7	7.7	Hj.	2940.7	7.4	Hj.
	2945.7	7.3	Hj.	2946.7	7.3	Hj.	2950.7	7.0	Hj.	2955.5	7.0	M.
	2955.6	7.1	Pc.	2956.5	6 5	Ca.	2962.6	7.1	Ca.	2966.6	7.3	Pc.
	2967.6	7.5	Bh.	2977.6	7.5	Ca.						
122532 T CANUM VENATICORUM—	2975.9	10.4	Pt.									
123160 T URSAE MAJORIS—	2907.1<11.6 Ch.			2953.6<10.8 Mu.			2956.5<10.8 Ca.			2956.6	13.1	Pc.
	2957.5 <9.8 Cg.			2963.5 <9.8 Cg.								

VARIABLE STAR OBSERVATIONS, September 20 to October 20, 1921—Continued.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.
123459 RS URSAE MAJORIS—								
	2907.1	10.3 Ch.	2938.3	9.2 Pe.	2941.3	9.2 Pe.	2947.7	9.2 Wf.
	2953.6	9.2 Mu.	2954.7	9.1 Wf.	2955.3	9.7 Pe.	2955.5	9.7 M.
	2955.6	9.5 Pc.	2955.6	9.6 Pt.	2956.5	9.4 Ca.	2957.5	9.9 Cg.
	2963.5	9.8 Cg.	2963.7	10.4 Wf.	2966.6	9.8 Pc.	2969.5	10.2 Ca.
	2969.7	10.5 Wf.	2971.6	10.0 Bh.				
123961 S URSAE MAJORIS—								
	2907.1	8.3 Ch.	2941.3	8.6 Pe.	2950.3	8.8 L.	2953.6	9.8 Mu.
	2955.3	9.6 Pc.	2955.5	8.9 M.	2955.6	8.9 Pc.	2955.6	9.0 Pt.
	2955.6	9.3 V.	2956.5	8.8 Gd.	2957.5	<9.7 Cg.	2959.5	9.5 Ca.
	2960.6	9.5 L.	2963.5	<9.7 Cg.	2966.6	9.7 Pc.	2969.5	10.3 Ca.
	2971.6	9.5 Bh.	2979.5	10.8 Gd.				
132422 R HYDRAE—								
	2905.1	8.3 Ch.						
132706 S VIRGINIS—								
	2908.1	<11.2 Ch						
133273 T URSAE MINORIS—								
	2955.6	10.0 V.	2956.8	10.1 Wf.	2958.5	9.6 M.	2966.8	9.5 Wf.
134440 R CANUM VENATICORUM—								
	2955.6	10.8 M.	2955.6	10.8 Pt.				
140113 Z BOOTIS—								
	2947.7	<12.5 Wf.	2956.6	14.0 Wf.				
141567 U URSAE MINORIS—								
	2905.1	10.2 Ch.	2955.6	11.8 Pt.	2956.6	11.3 Pc.	2957.5	11.5 Ya.
	2958.5	11.1 M.						
141954 S BOOTIS—								
	2905.2	11.2 Ch.	2927.1	9.6 Ch.	2935.4	9.0 Gi.	2947.3	9.3 L.
	2947.4	9.2 Gi.	2955.4	9.4 M.	2955.6	9.0 Pt.	2957.3	9.0 L.
	2957.5	9.3 Ya.	2963.4	8.6 Gi.				
142584 R CAMELOPARDALIS—								
	2947.4	8.2 Gi.	2947.8	8.4 Wf.	2948.8	8.4 Wf.	2949.7	8.2 Wf.
	2955.6	8.6 M.	2956.5	8.6 Ya.	2956.8	8.6 Wf.	2960.6	8.6 B.
	2963.4	8.6 Gi.	2965.6	8.7 O.	2966.8	8.7 Wf.		
142539 V BOOTIS—								
	2940.6	8.5 Hj.	2947.3	8.7 L.	2951.6	8.7 Pc.	2955.6	8.8 Pt.
	2956.5	8.2 M.	2956.5	8.8 Ya.	2957.3	9.1 L.	2960.5	8.7 Ca.
	2961.3	8.8 Pe.	2966.6	8.8 Pc.	2967.6	9.2 Bh.	2969.5	8.9 Ca.
	2979.5	9.3 Ca.						
143227 R BOOTIS—								
	2905.1	10.8 Ch.	2955.6	12.2 Pt.	2961.5	<11.3 Ca.		
144918 U BOOTIS—								
	2940.3	10.9 Gi.	2955.5	<10.5 M.	2957.3	11.7 Gi.		
151520 S LIBRAE—								
	2905.2	<10.4 Ch.						
151731 S CORONAE BOREALIS—								
	2905.2	<11.1 Ch.	2954.7	12.6 Wf.	2955.6	12.1 Pt.	2956.6	12.8 B.
	2956.6	13.0 Pc.	2958.5	<10.5 M.	2963.7	12.3 Wf.	2966.6	<11.1 Bh.
	2969.7	12.4 Wf.						
151714 S SERPENTIS—								
	2948.3	9.3 L.	2956.5	9.8 Ca.	2956.6	9.6 Wf.	2962.3	10.1 L.
	2966.6	10.3 Wf.	2969.5	10.4 Ca.				
152714 RU LIBRAE—								
	2946.3	9.5 L.	2962.3	10.2 L.				
153378 S URSAE MINORIS—								
	2952.5	8.6 Ro.	2955.6	9.6 V.	2955.6	8.6 Wl.	2955.6	8.5 Pt.
	2956.6	8.3 Pt.	2956.6	8.5 Ya.	2956.8	9.1 Wf.	2960.6	8.7 Ca.
	2963.5	8.9 Ro.	2964.9	8.9 Bh.	2966.8	9.7 Wf.	2977.6	9.3 Ca.
154428 R CORONAE BOREALIS—								
	2903.2	6.1 Ch.	2934.4	6.7 Pe	2937.6	6.9 Hj	2938.3	6.7 Pe
	2941.4	6.7 Pe.	2946.3	7.2 L.	2946.4	6.8 Gi.	2947.3	7.2 L.
	2947.7	7.2 Wf.	2948.3	7.2 L.	2948.8	7.3 Wf.	2949.7	7.4 Wf.

VARIABLE STAR OBSERVATIONS, September 20 to October 20, 1921—Continued.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.
154428 R CORONAE BOREALIS—Continued.								
	2950.3	7.1 Be,	2950.3	7.2 L,	2951.6	7.1 Pc,	2952.5	7.5 Gd,
	2952.7	7.6 Mu,	2953.7	7.3 Mu,	2954.3	7.5 L,	2954.6	7.3 Pc.
	2954.6	7.6 Wf,	2954.7	7.4 Mu,	2955.3	7.4 Pc,	2955.5	7.3 Gd.
	2955.6	7.8 Pt,	2955.7	7.5 Mu,	2956.4	7.6 L,	2956.5	7.7 Ca.
	2956.5	7.5 M,	2956.7	7.7 Wf,	2957.3	7.5 Be,	2957.4	7.7 L,
	2957.5	7.9 Ca,	2957.7	7.5 Mu,	2957.7	7.9 Wf,	2958.4	8.0 Pc.
	2958.5	7.6 M,	2958.5	7.8 Pt,	2958.6	8.1 Mu,	2958.7	7.8 Pc,
	2959.5	8.0 Ca,	2959.5	7.6 Gd,	2959.6	7.9 Pc,	2959.6	7.0 Su.
	2959.7	8.1 Mu,	2960.5	8.0 Ca,	2960.5	7.9 Pt,	2960.7	8.4 Mu.
	2961.3	8.1 Pc,	2961.4	7.8 L,	2961.6	8.5 Pt,	2961.7	<8.5 Mu,
	2962.3	8.2 Be,	2962.3	8.2 L,	2962.5	8.5 Ca,	2962.5	8.1 Ya.
	2962.6	<8.5 Mu,	2962.6	8.4 Pt,	2963.3	8.5 Gi,	2963.3	8.7 Pc.
	2963.5	8.5 Ca,	2963.6	8.4 Pc,	2963.7	8.5 Wf,	2964.5	8.2 Gd.
	2965.6	<8.5 Mu,	2965.7	8.9 Wf,	2966.5	8.9 Pt,	2966.6	8.7 Bh.
	2966.6	9.0 Pc,	2966.7	9.1 Wf,	2967.5	9.4 Ca,	2967.6	8.9 Bh,
	2967.7	<8.5 Mu,	2968.5	9.1 Pt,	2968.6	9.2 Bh,	2968.6	9.0 Lc.
	2968.6	9.1 Pc,	2968.7	9.5 Wf,	2969.5	9.3 Ca,	2969.5	9.1 Pt.
	2969.7	9.4 Wf,	2970.7	9.6 Wf,	2971.6	9.5 Bh,	2971.7	9.7 Br.
	2971.7	9.5 Wf,	2972.7	9.7 Wf,	2973.5	9.4 Pt,	2973.7	9.8 Wf,
	2977.5	9.3 Ca,	2978.5	9.4 Pt,	2979.5	9.4 Ca,	2979.5	9.4 Gd.
154536 X CORONAE BOREALIS—								
	2954.7	9.6 Wf,	2955.5	9.2 M,	2955.6	9.4 V,	2963.7	9.9 Wf.
	2969.7	9.8 Wf.						
154639 V CORONAE BOREALIS—								
	2954.7	8.5 Wf,	2955.5	7.7 Gd,	2955.5	7.3 M,	2955.6	7.1 Pt.
	2957.5	7.6 Ya,	2963.7	7.9 Wf,	2969.7	7.7 Wf.		
154615 R SERPENTIS—								
	2909.2	<11.3 Ch,	2956.6	<11.6 Ca.				
155018 RR LIBRAE—								
	2905.2	11.6 Ch,	2927.1	9.8 Ch,	2946.3	8.9 L,	2962.3	9.1 L.
155229 Z CORONAE BOREALIS—								
	2952.6	9.9 B.						
155847 X HERCULIS—								
	2941.3	6.3 Pc,	2952.7	6.4 Mu,	2953.7	6.4 Mu,	2954.7	6.5 Mu,
	2955.7	6.4 Mu,	2957.7	6.5 Mu,	2958.6	6.5 Mu,	2959.6	6.5 Su,
	2959.7	6.5 Mu,	2960.7	6.6 Mu,	2961.7	6.6 Mu,	2962.7	6.5 Mu,
	2963.3	6.5 Pe,	2965.6	6.6 Mu,	2967.7	6.4 Mu,	2968.6	5.8 Su.
160021 Z SCORPII—								
	2954.3	10.8 L,	2962.3	10.6 L.				
160118 R HERCULIS—								
	2909.2	9.7 Ch,	2956.6	12.4 B,	2958.6	12.0 Pc.		
160210 U SERPENTIS—								
	2956.6	11.8 Pc.						
160625 RU HERCULIS—								
	2953.6	12.1 B,	2954.8	11.8 Wf,	2955.5	12.3 M,	2955.6	12.2 Pt.
	2956.6	11.9 Pc,	2957.7	11.8 Wf,	2963.8	11.8 Wf,	2965.7	11.5 Wf,
	2966.7	11.4 Wf,	2968.7	11.0 Wf,	2969.7	10.9 Wf,	2970.7	10.8 Wf,
	2971.7	10.6 Wf,	2972.7	10.5 Wf,	2973.7	10.6 Wf.		
161138 W CORONAE BOREALIS—								
	2954.7	8.8 Wf,	2955.5	8.5 M,	2955.6	8.4 Pt,	2956.7	8.8 Wf,
	2957.6	8.4 Ya,	2958.7	8.4 Pc,	2963.7	8.5 Wf,	2969.7	8.4 Wf.
161122b S SCORPII—								
	2955.6	10.5 Pt.						
161122c T SCORPII—								
	2955.6	10.7 Pt.						
161607 W OPHIUCHI—								
	2952.6	<12.7 B,	2954.3	<13.2 L.				
162112 V OPHIUCHI—								
	2955.6	8.6 Pt.						

VARIABLE STAR OBSERVATIONS, September 20 to October 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
162119 U HERCULIS—												
	2908.2	<10.4	Ch,	2935.4	11.7	Gi,	2948.4	11.4	Gi,	2955.6	11.3	B,
	2955.6	11.6	M,	2955.6	11.8	Pt,	2956.6	<10.9	Ca,	2958.6	11.3	Pc,
	2962.3	11.5	Pe,	2963.4	11.4	Gi.						
162319 Y SCORPII—												
	2940.3	11.6	Gi,	2956.3	12.4	L.						
162542 g HERCULIS—												
	2963.3	5.2	Pe.									
162807 SS HERCULIS—												
	2954.3	11.4	L,	2955.5	11.1	M,	2955.6	11.1	Pt,	2962.3	10.7	L.
162815 T OPHIUCHI—												
	2957.3	<12.0	L.									
162816 S OPHIUCHI—												
	2957.3	<12.0	L.									
163172 R URSAE MINORIS—												
	2954.6	9.5	M.									
163137 W HERCULIS—												
	2906.3	8.4	Ch,	2928.1	8.6	Ch,	2954.6	9.7	M,	2954.6	9.8	Pc,
	2955.6	9.6	Pt,	2955.6	9.7	V,	2961.6	9.8	B,	2961.6	9.9	Gd,
	2966.6	9.8	Pc.									
163266 R DRACONIS—												
	2906.1	6.8	Ch,	2954.6	8.8	M,	2955.6	8.4	Pc,	2955.6	8.6	Wl,
	2956.6	9.2	Ya,	2958.6	9.0	Pt,	2960.6	9.1	Ca,	2961.5	8.9	B,
	2965.5	9.3	O,	2966.6	9.2	Pc,	2969.7	9.7	Ca.			
164055 S DRACONIS—												
	2954.6	8.6	M.									
164319 RR OPHIUCHI—												
	2948.3	10.3	L,	2956.6	9.8	B,	2958.6	9.4	Pc,	2962.3	9.9	L.
164715 S HERCULIS—												
	2947.4	11.5	Gi,	2955.6	10.6	B,	2955.6	10.9	Pt,	2958.6	10.6	Pc,
	2963.4	10.5	Gi,	2963.6	10.5	Ca.						
165202 SS OPHIUCHI—												
	2952.5	10.7	Gd,	2958.6	11.8	Pt.						
165631 RV HERCULIS—												
	2955.5	12.3	Gd,	2955.6	12.5	M,	2955.6	12.5	Pt,	2955.6	<11.2	V,
	2956.4	12.2	Pe,	2956.6	12.3	B.						
170215 R OPHIUCHI—												
	2956.6	12.4	Pc,	2964.5	12.9	B,	2965.5	<12.0	Gd.			
170627 RT HERCULIS—												
	2956.7	<14.0	Wf,	2966.7	<13.0	Wf.						
171401 Z OPHIUCHI—												
	2940.3	12.3	Gi,	2955.6	12.1	B,	2956.6	<11.2	Ca,	2956.6	11.7	Pc,
	2957.3	11.9	Gi,	2957.6	11.8	Wl,	2958.6	11.6	Pt.			
171723 RS HERCULIS—												
	2954.6	8.5	M,	2955.6	8.2	Gd,	2955.6	8.3	Pt,	2956.7	8.0	Wf,
	2961.6	8.0	B,	2963.3	7.8	Pe,	2965.6	8.0	Hu,	2966.7	8.1	Wf.
172809 RU OPHIUCHI—												
	2957.6	13.1	Wl.									
173457 TY DRACONIS—												
	2956.4	9.6	Pe.									
174406 RS OPHIUCHI—												
	2955.6	10.6	Pt.									
175111 RT OPHIUCHI—												
	2957.6	<13.0	Wl.									
175458a T DRACONIS—												
	2935.4	10.6	Gi,	2968.6	12.0	Wl.						
175458b UY DRACONIS—												
	2968.6	11.8	Wl.									
175519 RY HERCULIS—												
	2938.3	<12.1	Pe,	2955.3	<11.6	Pe,	2955.6	<12.1	M,	2955.6	13.8	Pt.
175654 V DRACONIS—												
	2968.6	11.7	Wl.									

VARIABLE STAR OBSERVATIONS, September 20 to October 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
180565 W DRACONIS—												
	2958.6	9.0	Pt.	2968.6	9.6	Wl.						
180531 T HERCULIS—												
	2928.2	11.5	Ch.	2947.3	13.0	L.	2954.6	10.3	M.	2955.3	<11.6	Pe.
	2955.6	12.6	Pt.	2956.6	<11.0	Ca.	2957.3	12.8	L.	2958.6	12.4	Pc.
	2962.4	12.4	Pe.	2965.6	11.5	Hu.	2976.6	11.5	O.			
180666 X DRACONIS—												
	2968.6	<13.5	Wl.									
180911 NOVA OPHIUCHI #4—												
	2935.4	11.9	Gi.	2952.6	12.0	B.	2956.4	11.5	L.	2958.6	11.4	Pt.
181031 TV HERCULIS—												
	2954.3	<13.5	L.	2955.3	<11.6	Pe.	2962.4	<11.6	Pe.	2963.4	14.5	L.
181136 W LYRAE—												
	2934.7	<10.1	Hj.	2937.7	<10.1	Hj.	2939.7	10.6	Hj.	2940.7	10.6	Hj.
	2946 7	<10.1	Hj.	2952.6	12.0	Gd.	2954.3	11.7	L.	2954.6	11.5	M.
	2955.6	12.0	B.	2955.6	11.6	Pt.	2956.7	10.5	Hj.	2958.6	11.3	Pe.
	2962.4	11.1	Pe.	2962.6	—10.5	Ga.	2965.6	10.5	Hu.	2973.6	10.5	O.
181103 RY OPHIUCHI—												
	2934.4	9.0	Gi.	2945.4	8.8	Gi.	2952.6	8.9	B.	2955.6	8.9	Pt.
	2956.7	9.1	Wf.	2957.6	9.3	Wl.	2958.4	9.0	Gi.	2965.5	9.6	Ya.
	2966.6	9.9	Wf.									
182224 SV HERCULIS—												
	2948.3	10.8	L.	2955.6	10.2	Pt.	2956.6	10.1	B.	2962.4	10.3	L.
182306 T SERPENTIS—												
	2957.6	13.0	Wl.									
183149 SV DRACONIS—												
	2963.6	11.9	Y.	2968.6	11.7	Wl.						
183225 RZ HERCULIS—												
	2956.6	<12.5	Y.									
183308 X OPHIUCHI—												
	2920.4	8 3	Bp.	2931.4	8.5	Bp.	2935.5	8.4	Bp.	2945.4	8.7	Bp.
	2947.4	8.6	L.	2952.5	9.1	Gd	2953.3	8.7	Bp.	2953.6	8.8	B.
	2954.6	8.3	M.	2955.6	8.9	Pt.	2957.4	8.7	L.	2965.6	8.8	Ya.
184243 RW LYRAE—												
	2952.6	12.6	B.									
***184205* R SCUTI—**												
	2923.6	6.1	Ms.	2924.4	6.1	Bp.	2924.5	6.1	Bp.	2924.6	6.4	Ms.
	2925.6	6.4	Ms.	2928.6	6.3	Ms.	2929.6	6.0	Ms.	2931.4	6.2	Au.
	2932.6	6.1	Ms.	2933.4	5.6	Bp.	2933.6	6.3	Ms.	2934.3	6.0	Bp.
	2934.4	6.2	Bp.	2934.4	6.3	Au.	2934.6	6.1	Ms.	2935.4	6.2	Bp.
	2835.5	6.1	Bp.	2935.6	6.2	Ms.	2937.3	6.2	Au.	2937.6	6.3	Ms.
	2938.3	6.7	Pe.	2938.6	6.2	Ms.	2940.3	6.2	Au.	2940.3	6.6	Pe.
	2940.6	6.0	Hj.	2840.6	6.2	Ms.	2941.3	6.3	Pe.	2942.6	6.2	Ms.
	2946.3	6.2	L.	2946.4	6.4	Gi.	2948.3	6.3	Bp.	2948.3	6.1	L.
	2948.4	6.3	Bp.	2948 4	6.3	Au.	2949.3	6.1	Au.	2949.3	6.3	Au.
	2950.3	6.2	Au.	2950.3	6.1	Be.	2950.3	6.1	L.	2950.4	6.2	Au.
	2950.6	6.0	Pc.	2951.4	5.9	Bp.	2951.5	6.1	Bp.	2952.5	6.1	Ro.
	2952.6	6.4	Mu.	2953.7	6.1	Mu.	2954.6	5.8	M.	2954.6	5.9	Pt.
	2954.7	6.0	Mu.	2955.3	6.3	Pe.	2955.6	6.2	Ms.	2955.6	6.2	Pt.
	2955.6	5.9	Pc.	2955.7	6.0	Mu.	2956.4	6.1	L.	2956.6	5.9	Ca.
	2956.6	6.2	Hj.	2957.3	6.0	Be.	2957.4	6.0	L.	2957.6	6.1	Ms.
	2957.6	5.8	Wl.	2957.7	6.1	Mu.	2958.4	6.0	Pe.	2958.6	6.0	Mu.
	2958.6	6.1	Pt.	2959.5	5.8	Ca.	2959.6	6.1	Ms.	2959.7	6.0	Mu.
	2960.5	5.8	Pt.	2960.6	5.8	Ca.	2960.7	6.0	Mu.	2961.3	5.9	Pe.
	2961.4	5.9	L.	2961.5	5.7	Ya.	2961.6	5.7	Ca.	2961.6	5.7	Pt.
	2961.7	6.1	Mu.	2962.6	5.7	Ca.	2962.6	5.9	Pt.	2963.3	5.5	Gi.
	2963.4	5.9	L.	2963.5	5.6	Ro.	2963.6	5.7	Ca.	2963.6	6.0	Mu.
	2963.6	5.7	Pc.	2964 6	5.9	Ms.	2964.7	6.0	Mu.	2965.6	5.7	Bh.
	2965.6	5.9	Ms.	2965.6	6.0	Mu.	2966.5	6.0	Pt.	2966.6	5.7	Bh.
	2967.5	5.7	Ga.	2967.6	5.5	Bh.	2967.6	5.8	Ms.	2967.7	5.8	Mu.
	2968.5	6.1	Pt.	2968.6	5.4	Bh.	2968.6	5.9	Ms.	2968.6	5.5	Pc.

VARIABLE STAR OBSERVATIONS, September 20 to October 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
184205 R SCUTI—Continued.												
	2968.6	5.6	Su,	2969.5	5.7	Ca,	2969.5	6.7	Pt,	2969.6	5.8	Ms,
	2970.6	5.8	Ms,	2971.6	5.6	Bh,	2972.7	5.3	Br,	2973.5	5.9	Pt,
	2973.6	5.8	Ms,	2974.6	5.5	Ms,	2975.6	5.3	Ms,	2976.6	5.3	Ms,
	2977.5	5.5	Ca,	2978.5	5.4	Pt,	2979.5	5.4	Ca.			
184300 NOVA AQUILAE #3—												
	2935.4	9.7	Gi,	2948.3	9.3	L,	2950.3	9.3	L,	2952.5	9.9	Ro,
	2954.6	9.3	M,	2954.6	9.7	Pt,	2955.6	9.8	Pc,	2957.5	9.1	Gd,
	2958.6	8.9	V,	2960.6	10.0	Ca,	2961.4	9.2	Pe,	2962.3	9.7	L,
	2963.5	9.9	Ro,	2965.6	9.3	Ya,	2967.6	9.0	Bh,	2973.5	9.6	Pt,
	2977.5	9.8	Ca.									
185032 RX LYRAE—												
	2909.1<12.5		Ch,	2955.6	12.9	Pt.						
185512a ST SAGITTARII—												
	2927.1<11.2		Ch,	2954.3<13.0			L,	2957.6<13.0			Wl.	
185634 Z LYRAE—												
	2956.3	12.8	L,	2970.6	12.3	B.						
185737 RT LYRAE—												
	2968.6	10.4	Wl.									
190108 R AQUILAE—												
	2952.5	6.1	Gd,	2954.6	6.2	M,	2955.6	6.1	Pt,	2955.7	6.0	Pc,
	2960.6	6.4	Ca,	2965.6	7.0	Ya,	2970.6	6.8	B.			
190529a V LYRAE—												
	2963.6<12.7		Y.									
190818 RX SAGITTARII—												
	2964.6<13.5		B.									
190819a RW SAGITTARII—												
	2964.6	10.6	B.									
190941 RU LYRAE—												
	2958.6	12.6	Pc,	2968.6	12.2	Wl.						
190925 S LYRAE—												
	2954.6<11.5		M,	2956.3<14.0			L.					
190926 X LYRAE—												
	2954.6	9.5	M,	2958.6	8.8	Pt.						
190967 U DRACONIS—												
	2906.2<11.8		Ch,	2965.6	13.0	Hu,	2968.6	12.8	Wl.			
191007a W AQUILAE—												
	2911.1	8.8	Ch,	2955.6	8.4	M,	2955.7	8.5	Pc,	2958.6	8.5	Pt,
	2964.5	8.7	Gd.									
191007b TY AQUILAE—												
	2911.1	10.4	Ch,	2958.6	10.5	Pt,	2964.5	10.8	Gd.			
191017 T SAGITTARII—												
	2956.7	11.9	Pc.									
191019 R SAGITTARII—												
	2909.2	8.6	Ch,	2949.5	7.8	Ca,	2955.6	7.8	Gd,	2955.6	7.8	Pc,
	2958.6	7.2	Pt,	2959.5	7.6	Ca,	2961.4	7.4	Pe,	2962.6	8.3	B,
	2963.3	7.8	Pe,	2964.5	7.8	Ya,	2965.5	7.8	Gd,	2967.5	7.6	Ca,
	2977.5	7.8	Ca.									
191033 RY SAGITTARII—												
	2927.2	9.1	Ch,	2954.3	10.2	L,	2955.6	11.6	Pt,	2957.3	11.6	L,
	2962.3	12.0	L,	2966.6<10.0			Bh.					
191350 TZ CYGNI—												
	2958.6	10.9	Pt,	2963.6	10.8	Y.						
191319 S SAGITTARII—												
	2955.6	11.1	Pc,	2958.6	11.5	Pt,	2959.4	11.3	Gi,	2959.5<11.1		Ca,
	2964.5<11.8		Ya.									
191321 Z SAGITTARII—												
	2940.4<12.4		Gi,	2959.4	12.8	Gi.						
191637 U LYRAE—												
	2955.6	10.0	M,	2958.6	9.9	Pt.						

VARIABLE STAR OBSERVATIONS, September 20 to October 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
192928 TY CYGNI—												
	2908.1	<11.9	Ch.									
193311 RT AQUILAE—												
	2909.1	10.8	Ch,	2954.6	8.0	M,	2958.6	8.0	Pt,	2961.6	7.8	B,
	2963.6	8.2	Pc,	2968.5	8.6	O.	2970.6	7.7	B.			
193449 R CYGNI—												
	2903.1	11.2	Ch,	2934.8	<10.9	Hj,	2939.8	<10.9	Hj,	2947.7	<9.1	Hj,
	2950.7	<10.9	Hj,	2955.6	<11.8	M,	2956.7	<12.1	To,	2958.6	13.0	Pt,
	2958.6	12.6	Pc,	2958.7	<12.4	To,	2959.7	<10.9	Ca,	2960.7	<12.4	To,
	2971.6	<10.9	Bh.									
193509 RV AQUILAE—												
	2955.6	10.3	M,	2958.6	10.3	Pt,	2964.5	10.0	Gd.			
193732 TT CYGNI—												
	2956.6	8.4	M,	2968.6	7.3	Hu.						
194048 RT CYGNI—												
	2902.2	7.3	Ch,	2934.8	7.9	Hj,	2939.8	8.5	Hj,	2940.5	8.1	Gi,
	2940.7	8.5	Hj,	2945.7	8.9	Hj,	2950.7	8.8	Hj,	2955.4	9.0	Rk,
	2955.6	9.0	M,	2955.6	9.1	V,	2958.5	9.2	Gd,	2958.6	9.1	Pt,
	2958.6	9.0	Pc,	2959.7	9.2	Ca,	2968.6	9.9	Hu,	2969.7	10.5	Ca.
194348 TU CYGNI—												
	2906.1	<11.2	Ch,	2934.4	<12.4	Rk,	2955.4	<12.4	Rk,	2955.6	<11.8	M,
	2958.6	14.0	Pc.									
194604 X AQUILAE—												
	2956.7	<14.0	Wf,	2958.6	<14.0	Pc,	2960.6	<13.0	Wl,	2966.7	<14.0	Wf.
194632 χ CYGNI—												
	2906.1	5.4	Ch,	2911.1	5.3	Ch,	2934.4	5.6	Pe,	2938.3	5.4	Pe,
	2940.7	5.6	Hj,	2941.4	5.8	Pe,	2947.7	5.6	Hj,	2950.7	5.9	Hj,
	2951.6	6.1	Pc,	2955.3	6.0	Pe,	2955.6	6.2	Lc,	2956.4	6.1	Pe,
	2956.6	6.4	M,	2956.7	6.2	Hj,	2956.7	6.1	To,	2957.6	6.2	Ya,
	2957.7	6.2	To,	2958.4	6.2	Pe,	2958.6	6.9	V,	2958.6	6.4	Pt,
	2958.7	6.3	Hj,	2958.7	6.2	To,	2959.6	6.5	Pc,	2959.7	5.8	Ca,
	2960.7	6.5	To,	2961.3	6.4	Pe,	2962.3	6.4	Pe,	2962.7	5.8	Ca,
	2968.6	6.5	Hu,	2968.7	7.0	Lc,	2969.7	7.0	Ca,	2971.7	7.1	B,
	2977.6	7.0	Ca.									
195116 S SAGITTAE—												
	2952.6	6.3	Mu,	2953.7	6.0	Mu,	2954.7	5.5	Mu,	2955.7	5.3	Mu,
	2957.7	5.5	Mu,	2958.6	5.8	Mu,	2959.7	6.0	Mu,	2960.7	6.1	Mu,
	2961.7	6.3	Mu,	2962.6	6.1	Mu,	2964.7	5.3	Mu,	2965.6	5.5	Mu,
	2967.7	5.9	Mu.									
195202 RR AQUILAE—												
	2960.6	13.0	Wl.									
195308 RS AQUILAE—												
	2956.6	12.1	B,	2958.6	12.0	Pt.						
195553 NOVA CYGNI #3—												
	2908.2	9.5	Ch,	2948.3	9.8	L,	2952.5	10.0	Ro,	2954.6	9.3	Pt,
	2955.5	9.8	Gd,	2955.6	9.8	Pc,	2955.6	9.7	Pt,	2957.5	9.7	Gd,
	2958.5	10.1	Gi,	2958.6	9.6	Pt,	2958.6	9.7	V,	2960.6	9.3	L,
	2961.6	9.8	Gd,	2961.6	9.8	Pt,	2963.5	9.9	Ro,	2967.8	9.7	Pt,
	2975.8	9.7	Pt,	2977.6	9.7	Ca,	2979.5	9.5	Ya.			
195849 Z CYGNI—												
	2906.2	11.9	Ch,	2940.6	8.6	Gi,	2948.8	8.5	Wf,	2955.6	8.9	M,
	2957.7	8.3	To,	2958.5	8.3	Gi,	2958.6	8.1	Pt,	2958.6	8.9	V,
	2960.7	8.2	To,	2963.7	8.5	Wf,	2969.7	8.6	Wf,	2970.7	8.4	B.
200212 SY AQUILAE—												
	2952.6	<12.5	B,	2956.3	13.0	L.						
200357 S CYGNI—												
	2955.6	<12.4	M.									
200514 R CAPRICORNI—												
	2940.4	12.4	Gi,	2957.4	12.7	Gi.						
200647 SV CYGNI—												
	2958.6	9.0	M,	2965.6	7.5	Hu.						

VARIABLE STAR OBSERVATIONS, September 20 to October 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
200715a S AQUILAE—												
	2940.5	10.5	Gi,	2951.5	10.2	Gd,	2955.6	9.8	Lc,	2956.6	10.8	M,
	2957.4	10.5	Gi,	2958.6	11.0	Pt,	2965.6	11.1	Ya,	2968.6	10.2	Lc,
	2970.6	10.3	B.									
200715b RW AQUILAE—												
	2955.6	9.2	Lc,	2956.6	9.3	M,	2965.6	9.2	Ya,	2968.6	8.9	Lc,
	2970.6	9.2	B.									
200812 RU AQUILAE—												
	2952.6	9.6	B,	2955.6	10.0	M,	2968.5	10.2	O,	2973.6	10.4	B.
200822 W CAPRICORNI—												
	2956.6<12.6 Y.											
200906 Z AQUILAE—												
	2957.4	12.2	Gi,	2958.6	11.5	M,	2962.5	13.0	B.			
200938 RS CYGNI—												
	2937.4	7.5	Au,	2940.3	7.4	Au,	2948.3	7.5	L,	2948.4	7.4	Au,
	2956.6	7.9	M,	2958.6	7.3	Pt,	2961.4	7.6	L,	2961.6	7.7	Gd.
200916 R SAGITTAE—												
	2955.6	8.8	Le,	2956.6	9.1	M,	2965.6	9.4	Ya,	2968.6	9.0	Lc.
201008 R DELPHINI—												
	2947.3	8.8	L,	2952.7	8.8	B,	2955.6	8.7	M,	2957.4	8.7	L,
	2958.5	8.8	Pt,	2973.6	9.1	B.						
201130 SX CYGNI—												
	2956.6<13.8 B.			2956.6<12.0 M,			2963.6<12.9 Y.					
201121 RT CAPRICORNI—												
	2946.3	6.8	L,	2952.5	7.6	Ro,	2955.6	7.7	Lc,	2956.4	6.9	L,
	2963.4	6.9	L,	2963.5	7.6	Ro,	2964.6	7.6	Ya,	2968.6	7.8	Lc.
201437a P CYGNI—												
	2906.2	4.9	Ch.									
201647 U CYGNI—												
	2952.5	10.8	Ro,	2955.7	11.0	Lc,	2958.6	9.6	M,	2961.6	10.2	Gd.
	2963.5	9.5	Gi,	2963.5	10.5	Ro,	2967.8	10.7	Pt,	2968.7	10.9	Lc.
202539 RW CYGNI—												
	2956.6	8.7	M.									
202622 RU CAPRICORNI—												
	2940.4	11.5	Gi,	2957.4	12.6	Gi.						
202817 Z DELPHINI—												
	2952.5	12.1	Gd,	2958.5	12.9	Pt,	2959.6	13.0	B.			
202954 ST CYGNI—												
	2956.6<12.0 M,			2963.6	13.3	Y.						
202946 SZ CYGNI—												
	2956.6	9.2	M.									
203226 V VULPECULAE—												
	2956.6	8.8	M,	2958.5	8.5	Pt.						
203847 V CYGNI—												
	2906.2	8.4	Ch,	2936.6	7.8	Gi,	2958.6	8.6	M,	2963.5	7.9	Gi,
	2971.7	8.0	B.									
203816 S DELPHINI—												
	2952.7	10.9	B,	2956.6	11.0	M,	2958.6	11.0	V,	2959.5	11.5	Gd,
	2973.6	10.9	B.									
203905 Y AQUARII—												
	2955.6	11.6	M,	2963.4	12.4	Pe.						
204016 T DELPHINI—												
	2956.6<12.0 M,			2956.8	13.5	Wf,	2960.6	13.0	B,	2963.4<10.9 Pe,		
	2966.8	13.1	Wf.									
204104 W AQUARII—												
	2956.3	13.8	L,	2957.4	13.9	Gi,	2958.4<13.0 Pe.					
204215 U CAPRICORNI—												
	2940.4	13.6	Gi,	2957.5<13.9 Gi.								
204318 V DELPHINI—												
	2934.5	10.1	Gi,	2946.4	9.8	Gi,	2958.4	9.7	Gi,	2960.6	10.1	B,
	2971.7	10.2	B.									

VARIABLE STAR OBSERVATIONS, September 20 to October 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
204405 T AQUARII—												
	2952.5	8.4	Ro.	2955.6	8.2	M.	2958.4	7.8	Pe.	2958.5	8.1	Pt.
	2959.6	7.6	Ca.	2959.6	7.7	Gd.	2963.4	7.7	Pe.	2963.5	8.0	Ro.
	2964.6	8.0	Ya.	2975.6	7.6	B.	2977.5	7.6	Ca.			
204846 RZ CYGNI—												
	2940.6	10.5	Gi.	2958.6	10.5	Gi.						
205017 X DELPHINI—												
	2958.5	10.5	Pt.	2959.5	9.9	Gd.	2973.6	8.7	B.			
205923 R VULPECULAE—												
	2940.5	10.2	Gi.	2956.6	11 6	M.	2957.4	11.7	Gi.	2958.5	12.0	Pt.
	2960.7	12.5	B.	2968.6	11.9	Hu.						
210129 TW CYGNI—												
	2956.6	<12.5	M.	2963.6	<13.0	Y.						
210116 RS CAPRICORNI—												
	2953.6	7.9	Mu.	2961.4	8.4	Pe.	2962.4	8 5	Pe.	2964.6	8.4	Ya.
210124 V CAPRICORNI—												
	2940.4	<12.7	Gi.	2958.4	13.1	Gi.						
210221 X CAPRICORNI—												
	2940.4	13.1	Gi.	2958.4	13.1	Gi.						
210382 X CEPHEI—												
	2963.8	11.4	M.									
210504 RS AQUARII—												
	2956.3	13.6	L.									
210516 Z CAPRICORNI—												
	2956.6	9.8	M.									
210868 T CEPHEI—												
	2906.1	9.0	Ch.	2950.3	9.9	L.	2955.5	<9.2	Cg.	2956.6	10.2	M.
	2957.5	<9.6	Cg.	2960.7	10.1	L.	2968.6	10.5	Bh.	2968.8	10.2	Pt.
210903 RR AQUARII—												
	2956.6	10.5	M.	2959.6	10.6	Gd.						
211614 X PEGASI—												
	2941.4	9.6	Gi.	2957.5	9.5	Gi.	2958.5	9.5	Pt.	2959.6	9.8	Y.
211615 T CAPRICORNI—												
	2964.6	<11.1	Ya.									
212030 S MICROSCOPII—												
	2965 6	10.9	Bh.									
213244 W CYGNI—												
	2914.3	6.9	Bp.	2917.4	7.2	Bp.	2920.4	7.0	Bp.	2930 3	7.0	Au.
	2931.3	7.0	Au.	2931.3	7.0	Bp.	2934.4	6.9	Au.	2937.3	6.8	Au.
	2938.3	6.7	Bp.	2940 3	7.0	Au.	2945.5	7.0	Bp.	2946.3	6.3	L.
	2948.4	6.7	Au.	2950.3	6.1	L.	2957.3	6.0	Be.	2957.4	6.1	L.
	2963.4	5.9	L.									
213678 S CEPHEI—												
	2936.4	8.2	Gi.	2956.6	9.3	M.	2968.8	8.6	Pt.			
213753 RU CYGNI—												
	2956.5	8.4	M.									
213843 SS CYGNI—												
	2903.4	11.4	Ch.	2934.4	11.3	Rk.	2934.5	11.8	Gi.	2935.6	11.8	Gi.
	2936.6	11.7	Gi.	2938 6	11.8	Gi.	2940 6	11.8	Gi.	2941.5	11.8	Gi.
	2942.6	11.8	Gi.	2943.6	11.7	Gi.	2944.6	11.8	Gi.	2945.3	9.9	Gi.
	2946.3	8.5	Gi.	2946.3	8.6	L.	2947.3	8.4	Gi.	2947 3	8.4	L.
	2947 8	8.1	Wf.	2948.3	8.4	Gi.	2948.3	8.4	L.	2948.8	7.9	Wf.
	2949.6	8.3	Wf.	2950.3	8.3	L.	2950 3	8.4	Be.	2950.7	8.1	Wf.
	2950.8	8.3	Hj.	2951.5	8.4	Gd.	2951.6	8.2	Pe.	2952.3	8.4	Rk.
	2952.5	8.4	Gd.	2952 5	8.2	O.	2952.5	8.5	Ro.	2952 6	8.7	B.
	2953.6	8.6	B.	2953.6	8.2	Pe.	2954.3	8.5	Be.	2954.3	8.6	L.
	2954.6	8.6	Pt.	2954.6	8.3	Pe.	2954 8	8.2	Wf.	2955.3	8.6	Rk.
	2955 5	8.4	Gd.	2955.6	8.8	B.	2955.6	8.7	Gi.	2955.6	8.3	M.
	2955.6	8.6	Pt.	2955.6	8.4	Pe.	2956.4	8.7	L.	2956 5	8.6	Ca.
	2956.6	8.9	B.	2956.5	8.6	Gd.	2956.5	8.5	M.	2956.6	8.7	Gi.
	2956.7	8.5	Pe.	2956.7	8.8	Pt.	2956.7	8.4	Wf.	2957.3	8.8	Be.

VARIABLE STAR OBSERVATIONS, September 20 to October 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
213843 SS CYGNI—Continued.												
	2957.3	8.6	Rk,	2957.4	8.8	L,	2957.5	8.6	Ca,	2957.5	9.0	Gi,
	2957.5	8.6	Gd,	2957.6	8.7	Ya,	2957.7	9.0	Wf,	2958.5	9.2	Gi,
	2958.5	9.6	Pt,	2958.6	9.2	L,	2958.6	9.1	M,	2958.6	9.1	V,
	2958.7	9.5	Pc,	2959.5	9.5	B,	2959.5	9.5	Ca,	2959.5	9.5	Gd,
	2959.6	9.5	Gi,	2959.6	9.6	Pc,	2960.5	9.8	Ca,	2960.5	10.0	Pt,
	2960.6	9.8	B,	2960.6	10.0	L,	2961.4	10.2	L,	2961.5	10.1	B,
	2961.5	10.2	Ca,	2961.5	10.1	Gd,	2961.6	10.6	M,	2961.6	10.3	Pt,
	2961.6	10.2	Pc,	2961.9	10.2	Wf,	2962.4	10.3	Rk,	2962.5	10.3	B,
	2962.5	<10.6	Ya,	2962.6	10.7	M,	2962.6	10.4	Pt,	2962.7	10.3	Ca,
	2963.4	10.7	L,	2963.5	11.0	B,	2963.5	11.0	Gi,	2963.5	10.6	Ro,
	2963.6	11.0	Pc,	2963.7	10.7	Wf,	2963.8	11.4	M,	2964.5	11.1	B,
	2964.5	11.1	Gd,	2964.6	11.2	Ya,	2964.9	10.9	Wf,	2965.5	11.5	Gd,
	2965.6	11.0	Hu,	2965.6	10.6	Wl,	2965.7	<10.0	Ms,	2965.8	11.3	Wf,
	2966.6	11.5	Pc,	2966.8	11.9	M,	2966.8	11.7	Wf,	2967.7	<10.0	Ms,
	2967.8	11.4	Pt,	2967.9	11.4	Wf,	2968.5	11.4	Pt,	2968.6	11.4	Pc,
	2968.7	<10.0	Ms,	2968.8	11.8	Wf,	2969.5	11.5	Ca,	2969.5	11.4	Pt,
	2969.7	<10.0	Ms,	2969.7	11.7	Wf,	2970.7	11.6	B,	2970.7	<10.0	Ms,
	2970.7	12.0	Wf,	2971.5	11.7	B,	2971.7	11.7	Wf,	2971.7	11.7	Y,
	2972.7	11.8	Gd,	2972.7	11.9	Wf,	2973.5	11.9	B,	2973.5	11.7	Pt,
	2973.8	11.9	Wf,	2975.6	11.9	B,	2975.7	<10.0	Ms,	2975.8	11.5	Pt,
	2977.6	11.7	Y,	2978.5	11.6	Pt,	2979.5	11.9	Gd.			
213937 RV CYGNI—												
	2956.6	8.1	M,	2965.6	7.8	Hu.						
214247 R GRUIS—												
	2966.6	11.4	Bh.									
215717 U AQUARII—												
	2940.7	10.5	M.									
215934 RT PEGASI—												
	2969.8	9.8	M,	2971.7	9.7	Y.						
220412 T PEGASI—												
	2956.3	13.1	L,	2957.5	13.0	Gi,	2960.6	13.4	B.			
220613 Y PEGASI—												
	2941.4	13.6	Gi,	2957.5	12.6	Gi,	2962.6	<11.1	M.			
220714 RS PEGASI—												
	2941.4	9.7	Gi,	2957.5	9.8	Gi,	2962.6	10.7	M.			
221722 RT AQUARII—												
	2956.6	10.0	M.									
222439 S LACERTAE—												
	2934.4	8.2	Gi,	2946.3	8.3	Gi,	2948.4	8.2	L,	2955.6	8.5	Gd,
	2960.6	8.9	L,	2971.6	9.6	B,	2975.8	9.8	M.			
223841 R LACERTAE—												
	2934.4	9.4	Gi,	2946.4	9.8	Gi,	2948.4	9.6	L,	2960.6	10.3	L,
	2971.8	9.7	M.									
225120 S AQUARII—												
	2956.6	<12.5	Y.									
225914 RW PEGASI—												
	2952.5	10.0	O,	2953.6	10.2	Mu,	2956.6	9.5	M,	2958.6	9.6	V,
	2959.6	10.4	Gd,	2960.6	9.5	B,	2971.7	9.8	Y.			
230110 R PEGASI—												
	2953.6	<11.0	Mu,	2956.6	<12.1	M,	2959.6	13.3	Y,	2960.6	13.0	Wl.
230759 V CASSIOPEIAE—												
	2941.4	11.2	Gi,	2952.5	11.5	Ro,	2955.6	12.2	B,	2958.5	12.8	Pt,
	2963.5	12.2	Ro,	2965.6	12.6	Wl,	2969.8	12.5	M.			
231425 W PEGASI—												
	2954.4	11.6	L,	2956.6	11.8	M,	2958.6	11.5	L.			
231508 S PEGASI—												
	2940.3	7.7	Pe,	2941.3	7.7	Pe,	2952.5	8.0	O,	2955.3	8.9	Pe,
	2956.6	9.1	M,	2958.4	8.9	Pe,	2958.5	8.5	Pt,	2959.6	9.2	Gd,
	2971.6	9.3	B.									

233335 ST ANDROMEDAE—
2952.5 10.6 O, 2955.6 9.8 B, 2956.6 10.5 M, 2956.8 10.5 Wf.
2957.5 11.1 Gd, 2958.5 10.3 Pt, 2966.8 10.0 Wf, 2968.6 9.5 Hu,
2971.6 9.3 B.

233815 R AQUARII—
2959.6 9.8 Gd, 2959.6 10.0 Ca, 2963.4 10.0 Pe, 2964.6 9.5 Ya,
2967.8 9.8 Pt.

233956 Z CASSIOPEIAE—
2947.8<13.4 Wf, 2956.8 14.2 Wf, 2957.7 14.0 Wf, 2958.5<12.1 M.
2960.6<13.4 B, 2963.8 14.0 Wf, 2964.9 14.0 Wf, 2965.8 13.7 Wf,
2967.9 13.8 Wf, 2968.8 13.6 Wf, 2969.7 13.5 Wf, 2970.7 13.5 Wf,
2971.7 13.3 B, 2971.7 13.3 Wf, 2972.7 13.3 Wf, 2973.8 13.4 Wf.

235053 RR CASSIOPEIAE—
2941.4 14.0 Gi, 2964.6<13.5 B.

235209 V CETI—
2946.4 10.2 Gi, 2956.6 11.5 L, 2964.6 11.4 Ya, 2967.8 11.9 Pt.

235350 R CASSIOPEIAE—
2945.3 6.8 Gi, 2954.6 6.4 M, 2963.6 6.3 B.

235525 Z PEGASI—
2952.5<11.5 O, 2956.6<11.6 M.

235715 W CETI—
2934.6 14.0 Gi.

235855 Y CASSIOPEIAE—
2941.4<12.8 Gi, 2958.6<11.0 M, 2964.6<13.5 B.

235939 SV ANDROMEDAE—
2959.6 9.0 Y, 2967.8 9.5 Pt.

Total Observations: 1598. Stars Observed: 293. Observers: 31.

The President, Mr. Leon Campbell, then called for reports. The Secretary, Mr. Olcott, stated that the membership is 268, an increase of 25 percent during the past year. Miss Cannon reported for the Telescope Committee that there have been added to the collection owned by the Association five telescopes and six photographic cameras, including the Charles Alfred Post collection. Professor Bailey, for the Slide Committee, stated that there are now 626 slides; that during the year slides have been loaned on fifty occasions, giving a total of 2231 slides exhibited. The report of the Chart Committee, of which the chairman is Mr. David B. Pickering, who was prevented by business from attending the meeting, was read by Mr. Yalden. Thirty-seven charts in 20 hours of R. A. have been completed, and 28 sets of photographic reproductions of the D. M. charts have been sold. Mr. McAteer, Librarian, has compiled a catalogue of the 373 volumes in the library. As soon as the catalogue is printed it is hoped that the members will avail themselves of the circulating library. The report of the Treasurer, Mr. Michael Jordan, showed an encouraging balance in all departments.

The Council has voted to award a sixth bar to the Nova Medal now held by Miss Woods, for the recent discovery of Nova Puppis, 1902.

Following the timely suggestion of Professor Bailey a Committee on Mechanical Construction was appointed by the Chair; namely—

Mr. Yalden, Chairman, Dr. Godfrey, Mr. Barns.

Professor Gerrish, of the Observatory staff, described a method for the precise adjustment, in a simple way, of the polar axis of a telescope used for visual work.

The members, at the invitation of Professor and Mrs. Bailey, adjourned for the noon recess to a delicious luncheon in their charming home. The Association regrets that the departure of Professor and Mrs. Bailey for Arequipa will deprive it of the presence of an ever-interested advisor.

At the continuation of the business meeting balloting for officers resulted in the following elections:

President, Leon Campbell, Cambridge.
Vice President, Anne S. Young, South Hadley.
Treasurer, Michael J. Jordan, Boston.
Council, S. C. Hunter, New Rochelle.
D. B. Pickering, East Orange.

The principal business of the meeting was the endorsement of a plan for the endowment of a memorial observatory to the late Edward C. Pickering, to whose efforts and encouragement much of the success of the Association is due. This observatory will serve to centralize the efforts of the Association and will specialize in the study of variable stars. The members were unanimous in their approval of such a memorial, and so voted. That now is the time to inaugurate this plan was unanimously agreed, and a committee will be appointed by the President to draw up a fitting appeal and to formulate plans.

Mr. Yalden read a timely paper, "Notes on Sidereal Time," and supplied copies of the summary which will be of much use to observers. Mr. Carlos Mundt contributed a paper, read by title, on "Picking Pets," advocating the selection, among the variables observed, of a few for special observation. Miss Maury gave an interesting talk on "The Spectroscope in Relation to Variables." Mr. Campbell showed a graphic representation of twelve nights' observation with the photometer of a short-period variable 224937—Lacertae. Following this Dr. Shapley showed a model and stated the relations as he had determined them for this binary system from Mr. Campbell's measures. Dr. Shapley also spoke on "Stellar Variation in Nebulae."

After the meeting Miss Cannon served tea in the photographic library, and later the members inspected the observatory, the Charles Alfred Post gift, and made some observations with the 12-inch telescope.

The Committee on Arrangements provided an excellent dinner at the Harvard Union. About sixty members and friends were present. Mr. Hunter, as toastmaster, called first upon Miss Young who encouraged members not possessing telescopes to observe the changing period of Algol. Mr. Regis Post spoke feelingly of the gratification it is to the family of the late Charles Alfred Post, his father, to have his telescopic equipment placed with the Association. Professor Bailey entertained the assembly with communications received from unbelievers and scoffers at the science of astronomy, who are more legion, even in Boston, than might be supposed. Mr. Olcott spoke as one who had seen the Association grow from its very inception. Dr. Harlow Shapley, recently appointed Director of Harvard College Observatory, was the guest of the evening. He recounted some of his experiences with variables, from theatrical to celestial, from observing to theorizing. He assured the Association of his interest and support. Professor Coolidge, of the department of Mathematics at Harvard, remarked that amateur work in Astronomy has unusual professional value, and is inspiring. Miss Cannon spoke appreciatively of the enthusiasm of the members, and of the presence of so many young people interested in Astronomy. Mr. Lindblad, of Upsala, Sweden, who has been at Mt. Wilson, told of the observatories and societies in Scandinavia.

The annual meeting closed with the passing of resolutions of appreciation to Harvard College Observatory, to Professor and Mrs. Bailey, to Dr. and Mrs. Shapley and to Miss Cannon for their hospitality. The next meeting will be held, at the invitation of Mr. Olcott, at his home in Norwich, Conn., on the

first Saturday in June, 1922, when he hopes to formally dedicate his new observatory.

The following are those who contributed to this report: Messrs. Aurino "Au," Bemporad "Bp," Benini "Be," Bouton "B," Brocchi "Br," Bunch "Bh," Carr "Ca," Chandra "Ch," Miss Clough "Cg," Ginori "Gi," Godfrey "Gd," Hoerl "Hj," Hunter "Hu," Lacchini "L," Lacy "Lc," McAteer "M," Mrs. Morris "Ms," Mundt "Mu," Olcott "O," Peltier "Pt," de Perrot "Pe," Proctor "Pc," Reesinck "Rk," Rhorer "Ro," Suter "Su," Townley "To," Vrooman "V," Waldo "Wl," Waterfield "Wf," Yalden "Ya," and Miss Young "Y."

ARVILLE D. WALKER, Recording Secretary.

COMMUNICATIONS.

A Slow Bright Meteor.—I was just riding into Martinsburg, West Virginia, on the Baltimore and Ohio Railroad train, due at 5:27 A.M. but 15^m late. At exactly 5:40 by my watch (which was correct within 15^s) I noted the time because I had just witnessed the following phenomenon.

I was seated in the smoker, on the eastern side of the train, with lights turned off. The first golden glow of dawn was lighting the horizon beneath the planet Venus, which I had been watching for five minutes or so, mentally commenting on her brilliance and magnitude and general splendor. The porter was the only other person in the smoker and as we were then so near the Martinsburg station he arose from his seat, which startled me from my reflections, causing me to turn my head an instant from looking at Venus. But instantly I glanced back to the sky and landscape primarily to see what kind of town we were running into, as it is my first visit here. But instantly my attention was distracted from that prospect by seeing a brilliant meteor, almost a perfect duplicate of Venus in size and color, but slightly less than half her elevation above the horizon. My first thought was "how did Venus drop that 20°?", although instantly aware that Venus was still there where I had been seeing her all the time. Almost as quickly also I noticed that the new object was moving very slowly towards the east and was located about 10° to the south of the vertical plane through Venus. The meteor's path however was so nearly in my line of sight that the motion seemed very, very slow, and the object itself was in sight for fully a minute. It did not burst but had a trail about 1° or 1½° long; I say "trail", although it was obviously and most clearly peculiar in not being "left behind" in direct line of its flight, but pointed upward and to the southward, almost at right angles to what I judged was its direct path. This tail was very clearly defined, having almost the effect of making the meteor look almost like a baseball bat with the handle end tapered to a point. I thought for an instant that the direction and length of this object was due to optical distortion by reason of my seeing it through the two thicknesses of glass of the Pullman car window, but Venus disproved such an assumption by continuing to present its clear, nearly full disc without any distortion. The meteor was moving so nearly parallel with the earth's surface and my line of sight that it changed its position in the sky only about 5°, and was lost to my view only by the increasing glow of the dawn and the interposition of objects on the earth as we ran into the stopping place at Martinsburg station,

where I left the train and am writing this at the hotel while awaiting breakfast.

There was no bursting or explosion perceptible. Before I turned my head, at the porter's motion, the object was not visible; the instant I turned my eyes back to the sky it was there in intense brightness and remained visible for so long a time as leaves no doubt of its reality or its nature, and it seems to me should have been visible to many persons through miles of territory along a line through Martinsburg, West Virginia, and Frederick, Maryland.

I am curious to know if any others report it to you or to other papers.

HERMAN S. DAVIS.

4323 Andover Terrace,
Pittsburgh, Pennsylvania, Oct. 6, 1921.

GENERAL NOTES.

Mr. A. Crommelin, assistant astronomer of the Royal Observatory at Greenwich, has been awarded the Pontecoulant Prize of the Paris Academy of Sciences in recognition of his general astronomical work.—(*Science*, Nov. 4.)

Luis Garcia Y. Carbonell, Director of the Observatorio Nacional of Cuba, died at Habana, Cuba, on October 11, 1921, at the age of 81 years. He was director of the National Observatory from 1905 to 1921.

Dr. Harlow Shapley has been appointed director of the Harvard College Observatory in succession to the late Professor Edward C. Pickering. Dr. Shapley received his early training in astronomy at the Laws Observatory, Columbia, Mo., and at Princeton, under Professor Henry Norris Russell. In 1914 he received an appointment at the Mount Wilson Observatory, where he devoted his time largely to the study of the globular star-clusters, by means of photographs taken with the 60-inch and 100-inch reflecting telescopes. His investigations led him to the conclusion that the star-clusters, although probably belonging to our galactic system and not outside universes, are nevertheless extremely remote, and so the scale of the stellar universe is much larger than had been previously supposed.

Dr. Shapley was invited last spring by President Lowell to spend a year at the Harvard University. He was given leave of absence from Mount Wilson and has since been carrying on his work at Cambridge in association with Professor Solon I. Bailey, acting director of the Harvard Observatory since the death of Professor Pickering.

Dr. Shapley is well qualified by his education, experience, and ability to plan and carry out extensive investigations, to become a worthy successor to the several famous men who have been at the head of Harvard College Observatory and given it standing among the great institutions of its kind.

Dr. Joel Stebbins has been appointed director of the Washburn Observatory and professor of astronomy at the University of Wisconsin, to succeed Professor George C. Comstock, who has been director of the observatory since 1889 and has reached the age of retirement. Professor Comstock will

carry on his work as director of the observatory during the present academic year, while Dr. Stebbins will act as non-resident professor of astronomy.

Dr. Stebbins has been a member of the department of astronomy and director of the observatory at the University of Illinois since 1903. He has done remarkable work in the study of the light variations of the stars with the selenium photometer and with photo-electric apparatus. He has been secretary of the American Astronomical Society since 1918, and is very active in promoting the interests of the society.

Professor Comstock has been a member of the Wisconsin faculty since 1887 and,in addition to his duties as director of the Washburn Observatory for 32 years, served as dean of the Graduate School from 1906 to 1920.

Lille Observatory.—We learn through *The Observatory* that this observatory, which suffered so severely during the war, is being reconstructed under the direction of Mr. Robert Jonckheere, the well known double-star observer.

The Astronomische Gesellschaft held its first meeting since 1913 at Potsdam on August 24-27. Representatives from sixteen nations were present. The next meeting is to be held at Copenhagen.(*Science*—Oct. 28.)

The Astronomische Nachrichten has published a jubilee number to commemorate the 100th anniversary of its founding. The first number appeared in September, 1821, with H. C. Schumacher, the founder, as editor. The jubilee number contains greetings and a great variety of articles from many well known astronomers in all parts of the world. Those contributing to this number are Armellini and Hagen, Italy; Bergstrand, Bohlin and von Zeipel, Sweden; Doberck and Eddington, England; Donner, Finland; Guthnick, Krüger and Küstner, Germany; Hough and Innes, South Africa; Ivanoff, Russia; v. Kövesligethy, Hungary; Oom, Portugal; Perrine, Argentina; Strömgren, Denmark; Nijland, Netherlands; Wolfer, Switzerland; and Barnard, See and Shapley, from this country. We extend our congratulations to our valued contemporary for the great service it has rendered to astronomy during its century-long career and sincerely wish for it a still greater future.

The American Association for the Advancement of Science will meet in Toronto from December the 27th to the 31st, in the University Buildings.

Section "D" is devoted to Astronomy.

The Royal Astronomical Society of Canada will meet at the same time and assist in the programme of the Association.

It is expected that a sufficient number of papers will be supplied by our members to occupy one or perhaps two sessions.

Toronto, November 15, 1921.

J. R. Collins, President R. A. S. C.
A. F. Hunter, General Secretary

The Yale University Observatory, under the direction of Professor Frank Schlesinger, has been opened to the public on two nights of each week, and one of the domes and telescopes has been fitted up for this purpose. To

make use of these facilities, one must write to the director some weeks in advance, enclosing a self-addressed envelope, indicating the preferred date and stating how many there will be in the party. Tickets will then be forwarded, which are valid for that night. (*Science* Nov. 11, 1921.)

Note Concerning the Total Solar Eclipse of Next Year.— The best conditions for observing the total solar eclipse of September 21, 1922, will probably exist at or near the telegraph-telephone station of Wallal, on the northwest coast of Australia. The altitude of the eclipsed sun will be 58 degrees, and the duration of totality, about 5 minutes 20 seconds, will be longer than at any other land area within the shadow path. The region is almost rainless in September, and the sky correspondingly cloudless. The prevailing winds are described as light. The apparent objections have related to the difficulties of transport to and of landing at Wallal, and of getting away from the observing station. Wallal is about 200 miles south-southwest from Broome, the nearest point of local steamer call. Settled habitations in the vicinity appear to consist of the government telegraph-telephone station of Wallal and of the Wallal Downs sheep station, three miles southwesterly from the telegraph station. There is no landing pier. The rise and fall of the spring tide is about 18 feet. The ordinary method of reaching the station would be by fortnightly steamer from Perth-Fremantle to Broome, thence by private arrangement on small schooner from Broome to an off-shore point near Wallal, and by surf boat from schooner to shore. This procedure is more complicated and perhaps more expensive than the usual eclipse expedition follows, but the evident astronomical advantages seemed to justify it if no better method could be found.

Certain of the Australian astronomers had expressed the hope that they could prevail upon their Government to supply transport by the Commonwealth Navy. Recent cablegrams from Father Pigot, Director of the Riverview College Observatory at Sydney, and from "Weather, Melbourne," have brought the welcome news, on the authority of Sir Joseph Cook, Acting Prime Minister of the Commonwealth, that the Australian Navy would transport the Lick Observatory-Crocker Eclipse Expedition from Fremantle to Wallal. It is probable that this generous proposal is meant to apply to all seriously-intentioned eclipse expeditions desiring to locate at Wallal.

W. W. CAMPBELL,
Chairman, Eclipse Committee,
American Astronomical Society.

Mount Hamilton, California
November 7, 1921.

The Twenty-seventh Meeting of the American Astronomical Society will be held at the Sproul Observatory, Swarthmore, Pa., December 29 to 31, 1921.

The following information is given in the "Circular of Information" recently issued by Secretary Joel Stebbins:

The headquarters for the meeting will be in Parrish Hall, the main building of Swarthmore College. Parrish Hall is about five minutes walk from the railway station, directly across the campus. The sleeping rooms and the dining rooms are in Parrish Hall. The flat rate from Wednesday evening until Saturday afternoon will be $12. This does not include supper on Wednesday evening but does include luncheon on Saturday noon. The domestic administration would be relieved of some embarrassment if members of the Society would

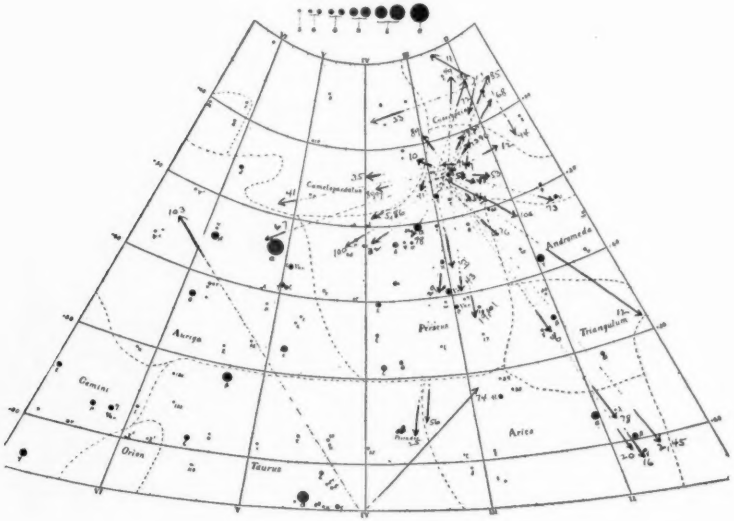
make their reservations early. Requests for reservations should therefore be sent to Professor Miller.

Swarthmore is located on a branch of the Pennsylvania Railroad, and is eleven miles from Broad Street Station, Philadelphia. Trains will leave Broad Street at: A. M., 6:20, 7:10, 8:21, 10:40; P. M., 1:00, 2:20, 2:45, 3:35, 4:30, 4:55, 5:10, 5:30, 5:46, 6:00, 6:30, 7:32, 9:00, 10:35, 11:55.

Mail, telegrams, or parcels post should be addressed to Swarthmore, care of American Astronomical Society.

There will be no occasion for formal dress at the meeting.

The Perseids, August 10, 11 and 12, 1921.—After several lean years the Perseids again began to show considerable activity and promise good yields for 1922. On July 28 the Perseids averaged 12 an hour, but after that



PERESEIDS AUGUST 10, 1921.

At sea 150 miles NE of Norfolk, Va., Radiant point at $2^h\ 47^m + 55°$

were very scarce even up to August 9, but the weather was unfavorable. The maximum occurred this year on August 10, probably in the day time on this side of the world, because they were fewer after 1 a. m. on August 11 and there were less bright ones. On August 12 they were scarce.

On August 10 observations were made at sea about 150 miles from Norfolk, Virginia. It was a perfect night until 3:25 a. m., when it clouded over. During this time 114 were observed and charted, when near the radiant point. One man watching the southwest counted over 60 an hour and saw some very brilliant ones. August 12 was mostly cloudy and foggy, but there were intervals when

SYNOPSIS OF PERSEIDS, AUG. 10, 11, 12, 1921.

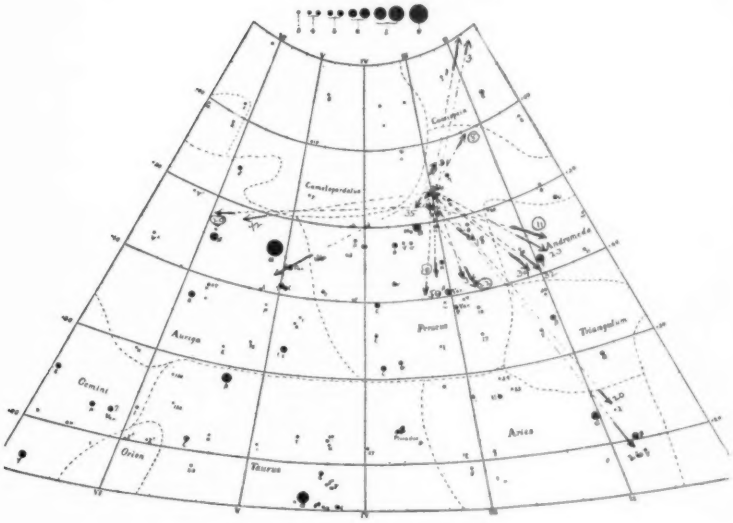
	−3	−2	−1	0	1	2	3	4	5	6	Total	Trails
Aug. 10	0	2	3	15	9	12	23	17	21	12	114	29
" 11	2	0	5	13	11	5	7	2	4	2	51	18
" 12	0	0	2	0	9	3	4	1	2	2	23	6
Totals	2	2	10	28	29	20	34	20	27	16	188	53

COLORS.

	W	Y	O	B	R	Total
Aug. 10	68	20	2	14	10	114
" 11	29	17	0	5	0	61
" 12	18	4	0	0	1	23
Totals	115	41	2	19	11	118

TIME AND NO.

12 mdt. - 1:00 A.M.	18
1:00 A.M. - 2:00 A.M.	27
2:00 A.M. - 3:00 A.M.	43
3:00 A.M. - 3:30 A.M.	26
	114



PERSEIDS AUGUST 11, 12, 1921.

August 11, 250 miles NE of Norfolk, Va., August 12, Ogunquit, Me. Ringed figures August 12. Radiant August 11, $2^h\,58^m + 54°$, August 12, $3^h\,02^m + 52°$.

the sky was brilliantly clear. 51 were counted with some bright ones, but they were fewer after 1 A. M. Observations were made when off the Jersey coast. On August 12 it was cloudy to partly cloudy, with a brilliant sky; 23 were counted, but they were scarce. This while at Ogunquit, Maine.

The radiant point on August 10 was very close to Eta Persei, 2 hours,

47 minutes R. A., and Declination +55; on August 11, 2 hours, 58 minutes R. A., and +54 Declination; on August 12, 3 hours and 2 minutes R. A., and +52 Declination. There were several bright ones August 10 which left trails lasting 2 to 5 seconds; number 84, below Pegasus left a trail which drifted east.

Wilmington, N. C. R. M. DOLE.

Parallaxes of 516 Stars.— In the *Monthly Notices of the Royal Astronomical Society* (London) for October 1921, Vol. LXXXI, No. 9, Dr. Arthur A. Rambaut gives a list of the parallaxes of 516 stars obtained from photographs taken with the 24-inch refractor of the Radcliffe Observatory, Oxford. These photographs are of 9 regions selected by Kapteyn and the exposures and reductions were made by his plan.

The magnitudes of the stars range from 6.8 to 12.4, the large majority lying between 10.0 and 12.0. The mean magnitude of the comparison stars is stated to be about 11.

The parallaxes as might be expected are generally very small, a large proportion coming out negative or less than the probable error of measurement. Yet we notice one parallax of $+0''.062 \pm 0''.011$ for a 11.5 magnitude star, one of $+0''.047 \pm 0''.010$ for magnitude 11.2, and several a little larger for stars of magnitudes brighter than 9.0.

Visibility of the Lunar Crescent.—In the October number of *The Observatory*, Dr. Fotheringham has collected a series of observation on this point. Two observations are listed when the age of the moon was less than fifteen hours, while the others range from $20^h 38^m$ to $24^h 58^m$. As all the observations are made without instrumental aid, it would be of interest for amateur astronomers to take up this matter, in order to determine how how frequently the crescent moon may be detected when less than 24 hours old.

Mars by William H. Pickering, published by Richard Badger, The Gorham Press, Boston, 1921, pp. 172.

This is a neatly printed book, written by a well-known astronomer and popular writer. In it the author has brought together all of the important papers on Mars which he has published in various magazines between 1890 and 1914. A considerable number of these were published in Popular Astronomy. The original papers have been revised and condensed, so as to bring them up to date and present to the reader in convenient form what is now known, or at least believed, concerning the physical conditions on the planet's surface.

Extra-Unclear.—"FROM AN OXFORD NOTEBOOK" in *The Observatory* for October, 1921, gives the following pat illustration of the effect of a printer's transposition of letters:

"Round a nucleus we can conceive extra-nuclear electrons—perhaps; but it is ingenious of the printer to make them extra-unclear."